THE PLANT DISEASE REPORTER

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Volume 42 Number 12

December 15, 1958

The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Crops Research Division serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

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(4) CAUSES OF DISEASES should be named. For bacteria, fungi, nematodes, etc., give the Latin name of the organism; for viruses either or both the accepted common name of the virus or a Latin name if you prefer it and there is one; for non-parasitic diseases state the causal factor if it is known. If the cause of a disease has not been determined say so.

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ACCEPTANCE OF MANUSCRIPTS

The increase in the volume of pertinent material offered for publication in the Plant Disease Reporter has made it necessary to limit the subject matter and the length of articles accepted. The subject matter should emphasize new things in plant pathology, such as new records of disease occurrence, serious outbreaks and epidemics, conditions affecting development of plant diseases, techniques of investigation including instrumentation, new discoveries in control including new materials and their evaluation. Manuscripts will be limited to 15 double-spaced typed pages. Insofar as possible, material should be presented as graphs rather than tables. Papers cannot be accepted for publication that report routine control experiments, reviews, bibliographies without annotation, results of routine surveys, mere summaries or lists of plant diseases. By following this procedure we hope to continue publishing all articles promptly.

Paul R. Miller

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PLANT DISEASE REPORTER
Mycology and Plant Disease Reporting Section
Crops Protection Research Branch
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THE PLANT DISEASE REPORTER

Crops Research Division — Plant Industry Station, Beltsville, Maryland
Volume 42 — December 15, 1958 — Number 12

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CEREALS

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FRUIT CROPS

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STATE CROP DISEASE SURVEYS

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LIMA BEAN SCAB FOUND IN SOUTH CAROLINA

W. R. Sitterly and W. M. Epps[1]

Lima bean scab, caused by the fungus Elsinoë phaseoli Jenkins, was found in variety trial plantings at the South Carolina Truck Crop Experiment Station at Charleston, South Carolina, on October 7, 1958. Insofar as the writers have been able to learn, this disease has not previously been reported in the United States, although it is widespread and destructive in Cuba, Puerto Rico and Central America.

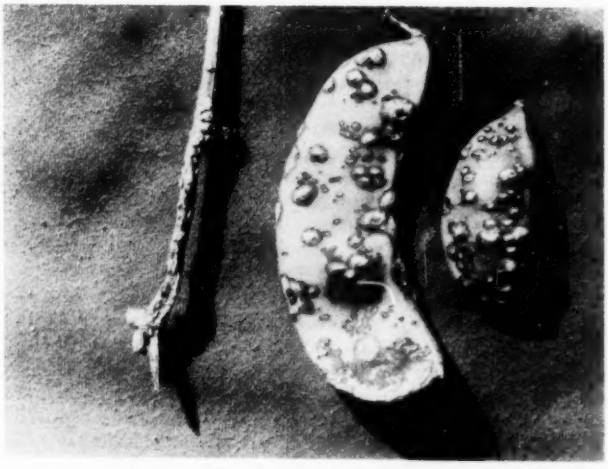

FIGURE 1. Scab, caused by Elsinoë phaseoli Jenkins, on the pods and stem of Fordhook lima beans.

Numerous lesions were first observed at harvest on the pods of the varieties Concentrated Fordhook and Fordhook 242 (Fig. 1). The pods of all other varieties in the test were clean. Stem and leaf lesions were found abundantly only on Fordhook 242 and Concentrated Fordhook. A search of the plots also revealed a few small lesions on the stems and leaves of Baby Green Fordhook. Widely scattered stem or leaf lesions occurred on the Clark's Bush, Nemagreen, and Thaxton varieties. No lesions were found anywhere on Early Thorogreen. The disease appeared most severe on the lower and more mature portions of the affected plants. The relative severity of the disease on the various varieties was approximately the same in all replicates of the test.

It is believed that the pathogen was probably brought in with the seed of Concentrated Fordhook, since it was so much more severely infected than the other varieties. Tests are now in progress with the residues of the seed lots to determine which lot is infected, if any.

An effort is being made to eradicate the pathogen from the infested area by means of sanitation and controlled crop rotation.

CLEMSON COLLEGE TRUCK EXPERIMENT STATION, CHARLESTON, SOUTH CAROLINA

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PINK-ROOT RESISTANT ONIONS FOR ARIZONA[1]

Robert B. Marlatt and Robert T. McKittrick[2]

Abstract

During a period of 4 years, eight varieties of early onions were grown in irrigated desert soil infested with the pink-root fungus, Pyrenochaeta terrestris (Hansen) Gorenz, J. C. Walker, & Larson. The varieties Crystal Wax, L690, and Texas Hybrid 23 were soon eliminated as unsatisfactory. Granex yielded significantly better than Texas Hybrid 28, Excel, L365 and Eclipse, despite the fact that it showed more pink root. Granex also stored significantly better than the other varieties at temperatures ranging from 75° to 85° F.

Pink root, caused by Pyrenochaeta terrestris (Hansen) Gorenz, J. C. Walker, & Larson (2), was found to be causing onion losses in scattered plantings throughout Arizona's Salt River Valley in 1953. Although some control of the disease has been reported through the use of fungicides (1, 6, 7) and crop rotation (5), the most satisfactory control method consists of the use of pink-root resistant varieties. Resistance to the disease has been found to vary with environmental conditions and with isolates of the pathogen (3). It was important to know how onion varieties performed when exposed to the fungus under irrigated, desert conditions.

VARIETIES AND METHODS

During the past 4 years (1954 to 1958), eight varieties of early onions were grown in randomized plots of pink-root infested soil in the Salt River Valley. Each variety was planted on one side of a standard 40-inch bed, 10 feet long, and was replicated at least six times. All of the varieties, except the long-known Crystal Wax, were developed by the United States Department of Agriculture and the Texas Agricultural Experiment Station. After the second test the three varieties Crystal Wax, L690, and Texas Hybrid 23 were discontinued when it became evident that they could not perform as well as the rest. Varieties which were grown during the last 2 years included two hybrids, Granex and Texas Hybrid 28. In addition, three open-pollinated varieties were grown: Excel, a yellow type; and L365 and Eclipse (L303), both white varieties. Each variety was rated for several characteristics: Pink root, yields, bolting, splitting and amount of decay in storage. Although the early varieties grown in warm areas of the United States are not considered to be storage onions, occasionally marketing is delayed in the hope of obtaining better prices. Therefore, behavior of the varieties in storage was important.

Pink root was evaluated during the first year of the test by examining the harvested dry bulbs for discolored roots. The pink, red or purple roots apparently were not as readily detected on yellow varieties as they were on white varieties. In subsequent tests, therefore, immature plants were pulled for examination several times during the season. During earlier stages of growth yellow varieties seemed to exhibit root symptoms as readily as did white varieties.

Bolting was recorded by counting the number of plants that had formed seed stalks shortly before harvest. Records were also kept of the number of decayed bulbs found during harvest and of those that had split. Healthy bulbs were sorted to three diameter sizes: Over 3 inches, 2 to 3 inches and 1 to 2 inches. Yield of each size was recorded and the total yields calculated.

Equal numbers of healthy bulbs from each plot were placed in net bags and stored at 75° to 85° F. They were examined twice during a period of 79 days and any decay was noted.

The onion varieties were evaluated for each of the above characteristics and compared by use of analysis of variance and Duncan's multiple range test.

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[1]Arizona Agricultural Experiment Station Technical Paper No. 498.

[2]Associate Plant Pathologist and Assistant in Research, respectively, Arizona Agricultural Experiment Station, Mesa, Arizona.

RESULTS

Pink Root: Symptoms of pink root were found annually on all varieties. The Granex variety showed significantly more root infection than did Excel, Texas Hybrid 28, Eclipse or L365. As has already been pointed out (4), however, Granex has enough vigor to tolerate considerable root injury.

Yields: Granex provided significantly higher yields of 3-inch and 2- to 3-inch bulbs despite its susceptibility to pink root.

Bolting: During the 1955-56 season Granex bolted more than Eclipse; the Texas Hybrids and L365 were intermediate regarding this characteristic. Not enough bolting occurred to be of much economic importance.

Splitting: Texas Hybrid 28 and Granex varieties contained significantly more split bulbs than did Excel, L365 and Eclipse. However, splitting was not common enough to be of concern to commercial onion growers.

Storage: During the 3 years that storage tests were made, Eclipse was rated the poorest because so many bulbs of that variety decayed. Significantly fewer Granex bulbs rotted in storage than did bulbs of other varieties.

Of the eight early onion varieties grown in pink-root infested soil, Granex yielded the greatest number of desirable bulbs and showed the least amount of decay in storage.

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PRESERVATION OF CONIDIA OF ALBUGO OCCIDENTALIS AND PERONOSPORA EFFUSA, OBLIGATE PARASITES OF SPINACH

Muriel J. O'Brien and Raymon E. Webb[1]

Summary

Preservation of obligate parasites of spinach, Albugo occidentalis and Peronospora effusa, by freezing was accomplished by placing infected spinach leaves at -10° F for 5 or 6 months. Germination counts were made at monthly intervals. Germination percentages dropped sharply after initial storage period and were low at the end of 5 or 6 months. Infection of healthy plants under greenhouse conditions was obtained, however, with white rust and blue mold conidia held for that period at -10°.

The technique permits preserving inocula for use at will in screening spinach introductions and segregating populations for resistance to disease. Screening work, therefore, can be conducted at short-day seasons of the year and in the cooler months with diurnal fluctuations in temperature, times favorable for plant growth as well as spore germination and disease spread.

INTRODUCTION

In breeding spinach, Spinacia oleracea L., for resistance to white rust, Albugo occidentalis G. Wils., and blue mold, Peronospora effusa (Grev. ex Desm.) Ces., it was found desirable to have available at Beltsville, Maryland, in early fall and winter viable inocula of these organisms to screen new introductions and segregating populations for resistance. Heretofore, it was necessary to search for blue mold inoculum in the Baltimore, Maryland canning-spinach area, and to await delivery of spinach leaves infected with white rust and blue mold after several days' air transit from Texas. A technique that would preserve conidia of the causal fungi with their physiological and biochemical characteristics unaltered, for use in making inoculations at favorable plant-growth periods and in the cooler seasons of the year, was therefore sought. Several practical methods which would not impose desiccation or extreme evaporation on the spores, including soil storage and freezing, were examined. Preservation by freezing (1, 2, 6) seemed to offer the best alternate to maintenance of the white rust fungus on living plants in a small air-conditioned chamber in the greenhouse and the search for blue mold infection in the field.

MATERIALS AND METHODS

Spinach leaves on which white rust sori and blue mold conidia were abundant were collected from greenhouse-inoculated plants and placed without delay at -10° F and stored for 5 or 6 months. Conidial suspensions in deionized and distilled water were also placed at the same time under the same freezing conditions. The leaf material and liquid suspensions were stored in screw-top glass food jars. At monthly intervals after storage some leaf tissue and liquid suspension were removed. In the refrigerating room blue mold spores were brushed from leaf tissue into a small amount of distilled water and white rust spores into deionized water while the leaf tissues were still hard-frozen. These suspensions were then held at 56° for 24 to 72 hours. Germination counts on blue mold spores were usually begun about 16 to 24 hours after placement of the material at 56°; germination counts on white rust were made 48 to 72 hours after similar treatment. Most blue mold spore counts were made only on leaf-tissue material, as it was apparent after 1 month's storage that there was a marked to total decline in germinability of spores in the liquid suspensions. Germination percentages were based on number of total spores and number germinated in ten fields in each of six drops of suspension on the slide.

In these tests the most common form of germination of blue mold conidia was by germ tube (Fig. 1). White rust conidia germinated by zoospores (Fig. 2), which later encysted and

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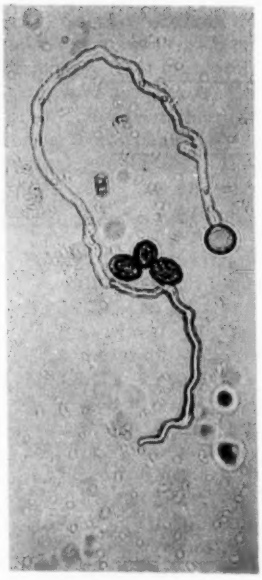

FIGURE 1. Conidium of Peronospora effusa germinating by germ tube. (From infected leaf tissue held at -10° F for 1 month)

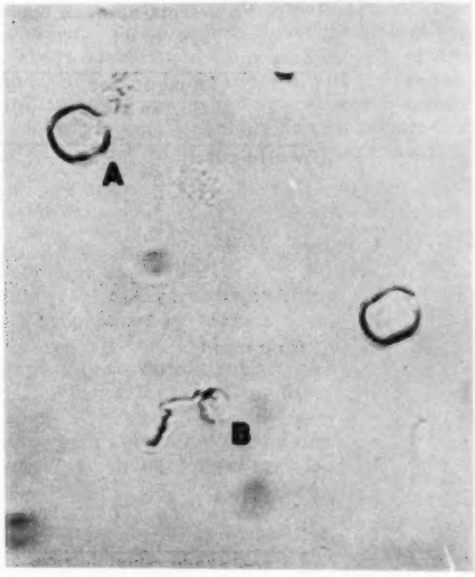

FIGURE 2. Germination of conidia of Albugo occidentalis. A -- Empty spore case from which cell contents have extruded. B-- Encysted zoospore which has produced a germ tube. (From infected leaf tissue held at -10° F for 1 month)

produced single hyphal branches. Only in one instance was germination by a germ tube found in white rust.

Reinfection of healthy spinach plants was accomplished at the end of the storage periods by spray inoculation with conidial suspensions of these fungi. After removal from -10° F the suspensions were held at 56° until spore germination took place. Inoculated flats of spinach were kept under conditions of high humidity by means of wet sheeting and plastic covering.

RESULTS AND DISCUSSION

Germination percentages based on monthly counts of the white rust and blue mold spores (Table 1) show a sharp decrease after an initial storage period. At the end of 5 or 6 months percentages were extremely low. Inoculation of healthy spinach plants under greenhouse conditions was made with conidial suspensions of white rust and blue mold from this stored infected leaf tissue after 5 and 6 months' storage, respectively. Infection of the healthy plants was obtained.

Germination of white rust spores in test and non-test material often reached 60 to 70 percent. These percentages were consistently higher than those reported (30 to 40 percent) by Raabe and Pound (5). Except for spore maturity, degree of wilting of leaf from which the spores were collected, and placement of suspensions at optimum temperature for spore germination, the factor contributing most to this increased germination percentage in white rust might be the use of deionized water. Blue mold spores, however, germinated equally well in distilled and deionized water and also germinated readily in tap water.

Rate of germination of stored white rust spores followed very closely the rate reported by Zalewski (7) for Albugo spp., namely, that often 3 days was required for spore germination in the fall. Our white rust test material was collected in late winter and early spring and often required 3 days for germination. Similar seasonal effects were reported by Melhus (3) and Napper (4), who found that spores of Albugo candida germinated faster in summer than they

Table 1. Germination of white rust and blue mold conidia from spinach leaves held at -10° F for various periods.

Fungus and period in storage (months)	Spores counted (number)	Spores germinating (percent)
White rust:		
0[a]	1206	50.9
1	1174	14.1
2	1467	14.7
3	975	18.9
4	1062	4.5
5	1243	2.1
Blue mold:		
0[a]	1522	19.1
1	1314	7.0
2	725	12.9
3	485	4.9
4	1058	2.6
5	1025	3.3
6	1059	3.4

[a] Prestorage counts.

Table 2. Germination of white rust and blue mold conidia from spinach leaves held at -10° F for 1 to 30 days.

Fungus and period in storage (days)	Spores counted (number)	Spores germinating (percent)
White rust:		
1	1008	38.9
2	1584	14.2
15	1114	13.7
30	792	14.1
Blue mold:		
1	1013	29.4
10	1167	14.6
15	252	11.5
20	143	13.2

did in other seasons. Our leaf material infected with blue mold likewise was collected in late winter and early spring. Germination of blue mold spores of this stored leaf tissue consistently took 16 to 48 hours.

The sharp decline in germination percentages of both blue mold and white rust spores after 1 month's storage prompted an investigation of germination during periods of less than 30 days. Therefore, blue-mold- and white-rust-infected spinach leaves were placed under the same conditions as were those for the long-term experiment, that is, storage at -10° F and germination of conidia at 56° Germination counts were made after 1 to 30 days (Table 2).

These data demonstrate that the sharp decrease in germination takes place almost immediately after the infected leaf tissue is placed in storage. After this initial loss in germinability, germination rates level off. A more critical time-germination study would be desirable to pinpoint the conditions under which loss of germinability commences and the related factor(s).

Spore survival and maintenance of viability over extended periods of time pose many problems. Survival factors for phycomycetous spores, because they germinate erratically even under optimum conditions, are extremely complex. The problems involved include (a) effect of macro- and microclimatic conditions on spore production; (b) periodicity of spore production, and number of aerial spores produced (in the case of blue mold); and (c) the possible role of inhibitor(s) in the spinach leaf. Viability of the preserved spores would appear to depend upon the absence of any great change in their gross morphology and biochemical and physiological properties. Refinement of freezing techniques might help to increase viability.

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FUNGICIDAL CONTROL OF BOTRYTIS LEAF ROT OF HOTHOUSE RHUBARB[1]

Harry H. Murakishi and Howard S. Potter

The most serious problem of hothouse rhubarb in Michigan is leaf rot, caused by Botrytis cinerea. Losses to individual growers may vary from 10 to 50 percent but a conservative estimate would place the average annual loss for the industry at 15 to 20 percent. These losses occur not only in the forcing house, but also to a large extent as transit rot during the marketing processes. Two crops are usually grown, an early house beginning in January and a late house starting in March and extending into early May. The disease is less severe in the winter months, but becomes serious in the early spring when rainy, cloudy weather prevails. During these periods, relative humidity in the hothouses may reach saturation during the nights and heavy infection results. Regulating humidity in the average hothouse is extremely difficult because the type of construction is not ideally suited for ventilation. For this reason the use of chemicals appeared to be the most feasible method of controlling this leaf disease problem. Fungicides tested in 1957 materially reduced infection from Botrytis (2). The most promising of these fungicides, together with certain additional materials, were tested further in 1958.

MATERIALS AND METHODS

Experimental work was conducted in two commercial rhubarb hothouses near Utica, Michigan. Plots were about 25 square feet in size, each containing approximately 30 plants. Plots were randomized and replicated three times for each treatment. A power sprayer equipped with a gun-type nozzle was used to apply fungicides. Treatments began as the first buds were forced and continued on a 7-day schedule until the end of harvesting, a period of about 1 month. Fungicides and rates of application used in these tests are given in Table 1.

Table 1. Evaluation of fungicides in controlling Botrytis leaf rot in two hothouses located near Utica, Michigan.

Fungicide[a]	Rate of application[b] (pounds/100 gallons)	Treatment means of disease ratings	
		House A[c]	House B[d]
Orthocide 50-W	2	1.80	.83
Manzate	2	2.75	1.34
Dithane Z-78	2	4.37	----[e]
Phaltan 50-W	2	1.18	.64
Terraclor	4	3.52	----
Dyrene	2	----[e]	1.12
Thylate	2	----	.56
Control		5.23	3.90
L.S.D. .05		.74	.33
L.S.D. .01		.98	.43

[a]Orthocide 50-W: 50 percent captan; Manzate: 70 percent maneb; Dithane Z-78: 65 percent zineb; Phaltan 50-W: 50 percent N-trichloromethylthiophthalimide; Terraclor: 75 percent pentachloronitrobenzene; Dyrene: 50 percent 2,4-dichloro-6-(o-chloroanilino)-5-triazine; Thylate: 65 percent thiram.

[b]Fungicides were applied on March 20, 26, April 3 and 9 for House A; and on April 3, 9, 16 and 23 for House B.

[c]Treatment means are based on disease ratings of leaves harvested on March 26 and April 9.

[d]Treatment means are based on disease ratings of leaves harvested on April 9, 23 and 30.

[e]Fungicide was not tested in this hothouse.

[1]Journal Article No. 2350, Michigan Agricultural Experiment Station. Technical assistance of Richard Crum is acknowledged.

Treatments were evaluated by harvesting 12 to 14 leaf-stalks from each plot after spraying and packing these in individual standard 5-pound rhubarb boxes which were then held in storage for 5 to 7 days at temperatures ranging between 65°-70° F. Ten leaf-stalks (or 30 per treatment of each harvest) were selected at random from each box and rated for degree of leaf rot using a modified version of the grading system developed by Horsfall and Barratt (1). They were graded into groups based on the percentage of leaf area showing infection as follows: 0 = 0 percent leaf rot, 1 = 0-3 percent, 2 = 3-6 percent, 3 = 6-12 percent, 4 = 12-25 percent, 5 = 25-45 percent, 6 = 45-65 percent, 7 = 65-85 percent, 8 = 85-92 percent, 9 = 92-96 percent, 10 = 96-98 percent, and 11 = 98-100 percent.

RESULTS

Of the fungicides tested in both hothouses, Phaltan gave the best control (see Table 1 and Figure 1). This was followed in descending order of effectiveness by Orthocide 50-W, Manzate and Dithane Z-78. The difference between Phaltan and Orthocide 50-W was significant in house A but not in house B. In house A, the fungicides, in their order of effectiveness, ranged from Phaltan, Orthocide 50-W, Manzate, Terraclor, Dithane Z-78 and control. In house B, they ranged from a group of equally effective materials, Thylate, Phaltan and Orthocide to Manzate and Dyrene followed by the control. In both houses the difference between any spray treatment and the control was significant or highly significant. Even though Phaltan gave outstanding control, the presence of a slightly visible residue was judged objectionable from the standpoint of buyer appeal.

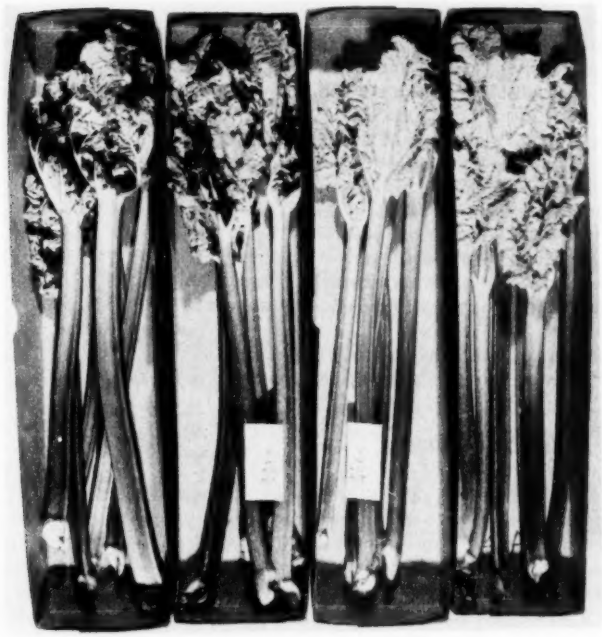

FIGURE 1. Left two boxes -- unsprayed controls; right two boxes -- from Phaltan-sprayed plots. Photographs made after sprayed and unsprayed series were held in common storage at 65°-70° F for 7 days.

CONCLUSION

Results of 2 years of spray tests for the control of leaf rot on rhubarb indicate that a number of fungicides will materially reduce losses from this disease when applied on a weekly schedule. Of these materials only captan has so far been approved by the Food and Drug Administration for use on hothouse rhubarb.

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THE FUSARIUM WILT COMPLEX AS RELATED TO THE SWEETPOTATO[1]

G. M. Armstrong and J. K. Armstrong[2]

Summary

Ninety-two pathogenic isolates of wilt Fusaria from sweetpotato and 28 from flue-cured tobacco were tested during 1945 and 1946 on Porto Rico sweetpotato. Fifty-nine of the sweetpotato isolates were tested on Kentucky 5 burley and Gold Dollar flue-cured tobacco; all were pathogenic on burley, but only 23 were pathogenic on flue-cured tobacco. All the tobacco isolates were pathogenic on flue-cured tobacco and sweetpotato, and those that were tested on burley tobacco were also pathogenic on this host.

The isolates that caused wilt of sweetpotato and burley tobacco are designated as race 1, and those that also caused wilt of flue-cured tobacco as race 2.

Most of the isolates from sweetpotato were from plants collected in 30 counties in South Carolina. Race 2 was isolated not only from both sweetpotato and tobacco collected in counties where tobacco is grown, but also from sweetpotato in counties where no tobacco is grown.

Additional isolates used to inoculate wilt-resistant varieties of sweetpotato in 1955-57 showed decided differences in the degree of virulence regardless of race, but these differences were not evident on the susceptible Porto Rico variety. Although the average percentages of wilt indicate that race 1 was somewhat more virulent on resistant sweetpotatoes than race 2, this difference might not have been as great if a larger number of isolates and plants had been used.

The problem of reduction in pathogenicity of cultures is discussed.

The host relationships of these races and those from cotton, alfalfa, soybean, and cowpea are compared.

INTRODUCTION

Early cross-inoculation experiments, which were started in 1938, indicated that the wilt Fusaria from sweetpotato (Ipomoea batatas), tobacco (Nicotiana tabacum), and cotton (Gossypium hirsutum) were related by having a common host, burley tobacco. Since this early work, numerous isolates of other wilt Fusaria have been used in the cross inoculations of sweetpotato and other hosts. Only those papers relating to the host relationships and the identification of the sweetpotato Fusaria will be reviewed at this time.

METHODS

Methods of growing plants in steamed sand and inoculating them with a liquid inoculum have been described (2). The medium for the inoculum was as follows: sucrose or dextrose, 2 percent; $MgSO_4$, 0.003M; KCl, 0.022M; KH_2PO_4, 0.008M[3]; $Ca(NO_3)_2$, 0.0356M[3]; $FeCl_3$, $MnSO_4$ and $ZnSO_4$, 0.2 ppm each of cations. Monoconidial isolates were the source of the inoculum except in a few instances where the corresponding mass cultures were tested for comparison.

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[1] Contribution of the Department of Botany and Bacteriology in cooperation with Crops Research Division, Agricultural Research Service, United States Department of Agriculture. Technical Contribution No. 289, South Carolina Agricultural Experiment Station.

[2] Plant Pathologist, South Carolina Agricultural Experiment Station, and Plant Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, respectively.

[3] Misprint in 1948 Phytopathology 38: 809, where these salts were 0.1008M and 0.10356M respectively.

Inoculation of Sweetpotatoes

After being rooted in steamed sand, vine cuttings of sweetpotato were rinsed in water, the basal ends were clipped with sterilized scissors, and the roots were dipped in the inoculum. Usually five to seven plants were set in steamed sand in a 2-gallon glazed pot which was placed under a shade for a few days and then on the greenhouse bench. The experiments were terminated at first in about 2 months after the plants were inoculated, but later in about 1 month, since wilt symptoms appeared quickly if the variety was susceptible to the isolate.

Steinbauer (17) investigated the reaction to wilt injury of sweetpotato plants originating from cuttings at different nodes on the vine and concluded that those from the vine tip gave the most sensitive evaluations. His "routine composite" samples, which included plants from cuttings at various positions on the vines but with a high proportion originating from the vine tips, gave only slightly less consistent results. Most of the cuttings used in the present investigations were from vine tips, but young sprouts from bedded sweetpotatoes also were used. Since there were no differences in the results with the two types of plants, the combined data are presented.

Inoculation of Tobacco and Other Plants

Tobacco seed was sown in trays of steamed sand. In the early experiments (2, 7), plants 4 to 5 inches tall were removed from the tray, the roots were dipped in the inoculum, and five to seven plants were set in a pot which was placed under a shade for a few days. With this method, some plants often did not recover from the shock of transplanting; therefore, in later experiments young plants were allowed to become well established in the pots, the roots were then cut on one side, and the inoculum was poured on the injured roots. This inoculation procedure was also used for other plants which were not transplanted but, rather, were derived from seed sown in the pot.

RESULTS OF INOCULATIONS

Experiments of 1945-46

In the summer of 1944, Nusbaum (14) made a survey of sweetpotato wilt on 174 farms in 22 counties in the Coastal Plain section of South Carolina. Wilting sweetpotatoes were found on 42.5 percent of the farms, and plants from all these locations were sent to the writers who made isolations of Fusaria from them. Other workers collected wilted plants from farms in the Piedmont section of the State, so eventually there were sweetpotato isolates from 30 counties. Also included in the tests were 28 pathogenic tobacco-wilt isolates from plants grown in South Carolina, North Carolina, Georgia, Maryland and Virginia. Twenty-two of the 114 sweetpotato isolates which were tested on the Porto Rico variety of sweetpotato were nonpathogenic and were discarded; all tobacco isolates were pathogenic. Some of these isolates were not tested on Kentucky 5 burley tobacco since, with one exception, it proved to be as susceptible as sweetpotato. Several monoconidial isolates obtained from sweetpotatoes in Saluda County, South Carolina were highly pathogenic on sweetpotato but caused wilt of only a small percentage of the tobacco plants when the usual inoculation procedures were used in the greenhouse. The Gold Dollar variety of flue-cured tobacco was susceptible to all 28 tobacco isolates but to only 23 of the 59 sweetpotato isolates.

The reaction of flue-cured tobacco to the isolates from wilting sweetpotatoes indicated the presence of 2 races; those isolates that caused wilt of sweetpotato and burley tobacco only are designated as race 1, and those that caused wilt of sweetpotato, burley tobacco, and flue-cured tobacco as race 2.

Figure 1 shows the 30 counties in South Carolina where sweetpotato wilt Fusaria were obtained. Records of the South Carolina Crop Pest Commission[4] show wilt in 12 of the remaining 16 counties, and Fusarium wilt can probably be found in every county in the State. The vertical hatching indicates the 14 counties where isolates of race 2 were obtained; however, this is not a complete record since some of the sweetpotato isolates were not tested on flue-cured tobacco. Race 2 was found not only in counties where most of the flue-cured tobacco is grown, but also in several other counties outside the tobacco area.

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[4] Data supplied by J. A. Berly, South Carolina Crop Pest Commission.

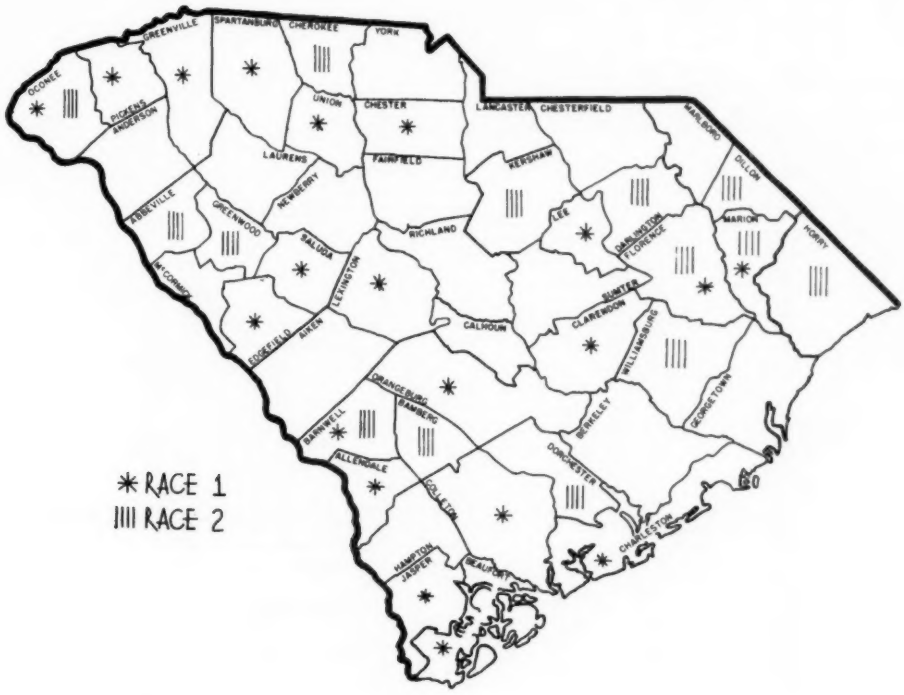

FIGURE 1. Counties in South Carolina where races 1 and 2 of the sweetpotato wilt Fusaria were obtained.

Experiments of 1955-57

Relative Pathogenicity of Races: The possibility that the 2 races differ in pathogenicity on some of the recently introduced wilt-resistant varieties of sweetpotato has been advanced since appreciable damage from wilt has been noted on resistant varieties in some fields. The instances called to the writers' attention occurred in the flue-cured tobacco section, and the assumption was made that perhaps race 2, which attacks flue-cured tobacco, was more virulent on sweetpotato than race 1.

In 1955 and 1956 Fusarium isolates were obtained from collections of wilted sweetpotatoes and tobacco at several locations in South Carolina and checked for pathogenicity shortly thereafter. There were six monoconidial isolates from sweetpotato, five of which were from recent South Carolina collections and one (7313b) from Beltsville, Maryland (No. 6 in Table 1) about 10 years old; and ten monoconidial and three mass isolates from flue-cured or Maryland Mammoth tobacco, all of which were recent South Carolina collections, except two from Maryland (Nos. 12 and 13 in Table 1) which were 19 years old.

The resistant varieties of sweetpotato Tinian, B6313, Gold Rush, and CaroGold, and the very susceptible one, Porto Rico, were inoculated with all the fungus isolates. The Gold Dollar variety of flue-cured tobacco was used to separate the races, and occasional inoculations of this variety were made during the tests to check the possible loss of pathogenicity of the isolates for this host.

The results are presented in Table 1 and Figures 2 and 3. The bar graphs in Figure 2 represent the percentages of plants that showed external symptoms of wilt. Isolates 1 to 6 inclusive were from sweetpotatoes, 1 to 5 belonging to race 1 but 6 belonging to race 2. Isolates 7 to 16b inclusive from tobacco belong to race 2. Isolates 12 and 13 were from tobacco in Maryland and the others from flue-cured tobacco in South Carolina. The "a" cultures are

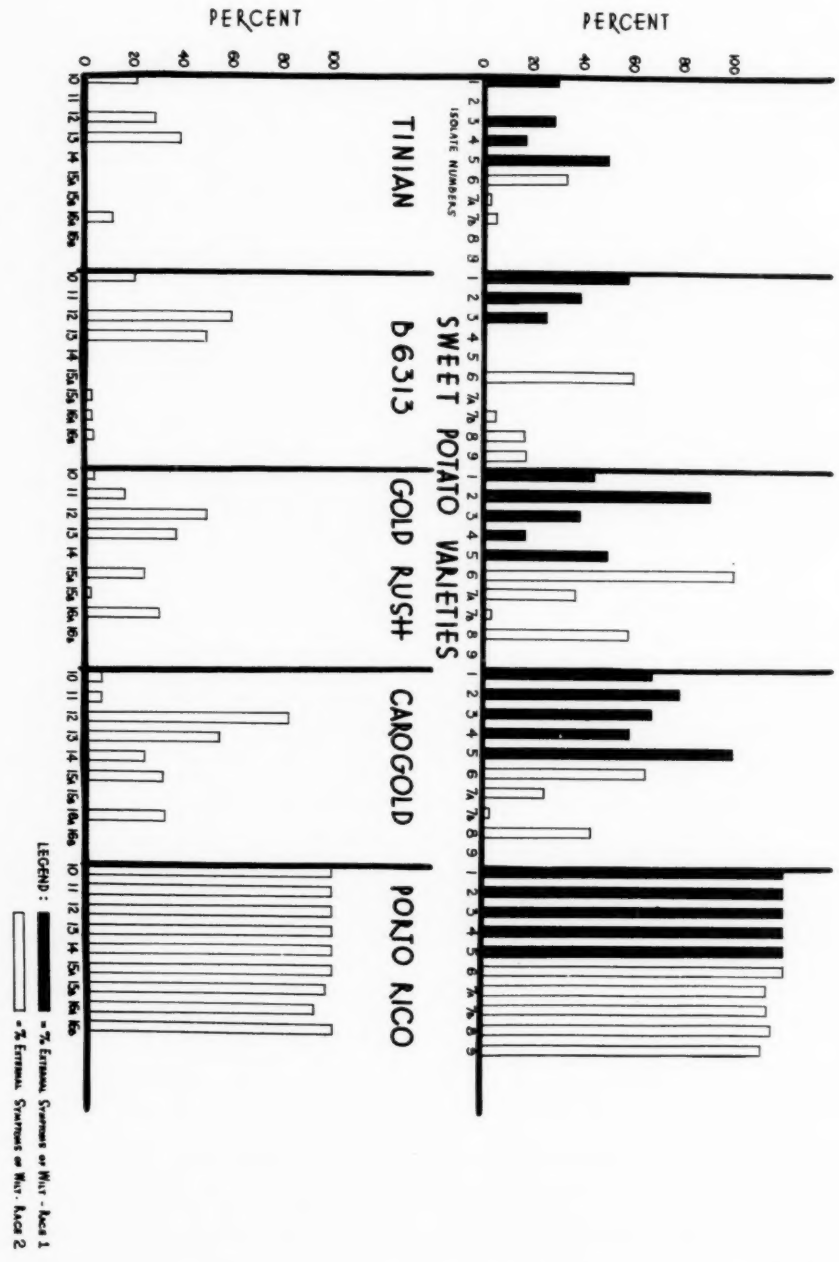

FIGURE 2. Percent external symptoms of wilt of sweetpotato inoculated with Fusarium isolates of races 1 and 2. Absence of bars above isolate numbers indicates no external symptoms of wilt.

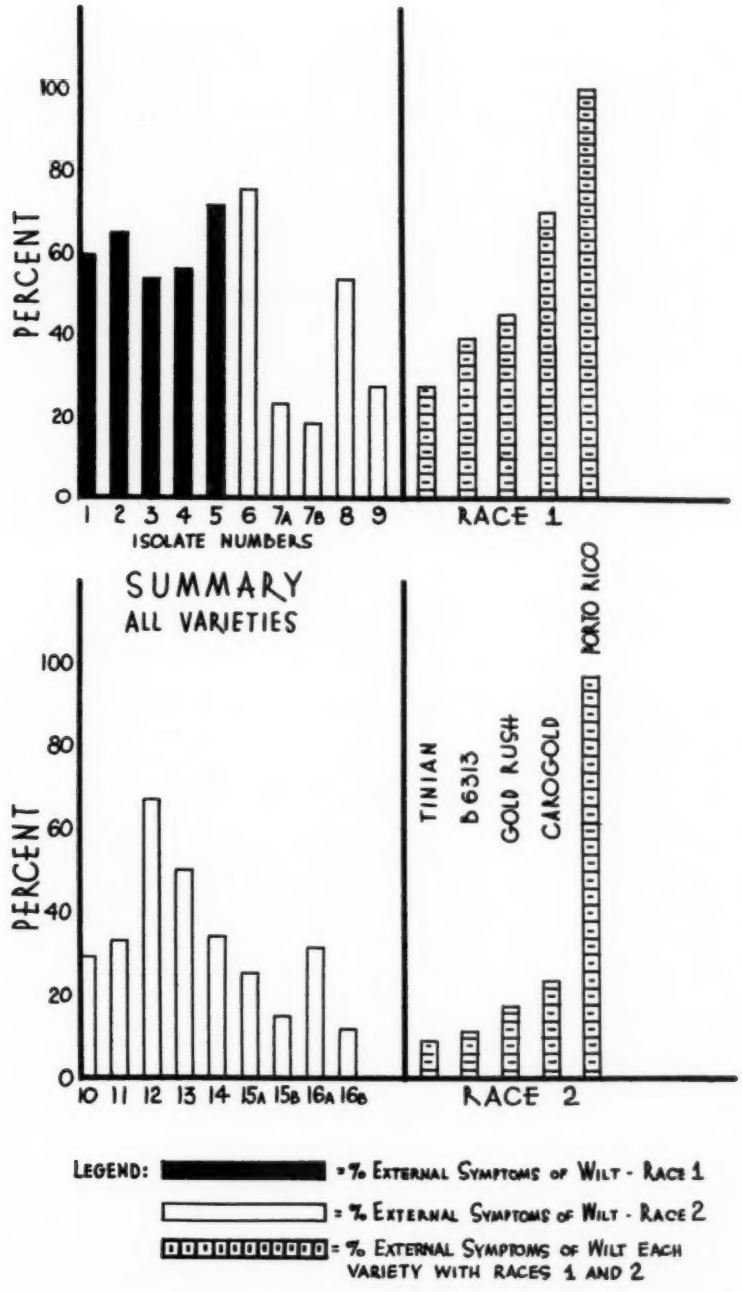

FIGURE 3. Summary. Percent external symptoms of wilt of sweetpotato varieties inoculated with each isolate of races 1 and 2, and of each variety with all isolates of races 1 and 2, respectively.

Table 1. Results of inoculations of sweetpotato and tobacco with Fusarium wilt isolates from both hosts. Isolates 1 - 5 inclusive are race 1 and isolates 6 - 16[b] inclusive are race 2. Isolates 1 - 6 are from sweetpotato, and isolates 7[a] - 16[b] are from flue-cured and Maryland Mammoth tobacco.

	Varieties of sweetpotato															Variety of tobacco		
	Tinian			B-6313			Gold Rush			CaroGold			Porto Rico			Gold Dollar		
olate number	Percent external symptoms	Percent[c] internal symptoms	Total number of plants	Percent external symptoms	Percent[c] internal symptoms	Total number of plants	Percent external symptoms	Percent[c] internal symptoms	Total number of plants	Percent external symptoms	Percent[c] internal symptoms	Total number of plants	Percent external symptoms	Percent[c] internal symptoms	Total number of plants	Percent external symptoms	Percent[c] internal symptoms	Total number of plants
1	31.1	63.9	61	58.0	40.6	69	44.3	52.0	70	67.4	32.6	92	100	--	57	0	46.1	13
2	0	100	14	38.5	61.5	13	90.9	9.1	11	78.3	21.7	23	100	--	18	3.0	33.3	33
3	28.8	63.5	52	25.4	74.6	63	38.7	56.5	62	66.7	33.3	60	100	--	70	0	100	12
4	16.7	66.7	6	0	100	6	16.7	83.3	6	58.3	41.7	12	100	--	18	0	0	30
5	50.0	50.0	6	0	100	6	50.0	50.0	6	100	--	12	100	--	12	0	0	6
6	33.3	66.7	3	60.0	40.0	5	100	--	7	64.3	35.7	14	100	--	7	88.9	11.1	18
7[a]	3.8	61.5	26	0	88.5	26	37.5	62.5	8	24.2	69.7	38	92.3	7.7	13	100	--	6
7[b]	5.7	71.4	35	5.0	85.0	40	3.7	51.9	27	2.2	68.9	45	93.3	6.7	30	78.1	0	32
8	0	91.7	12	16.7	83.3	12	58.3	41.7	12	62.5	37.5	24	94.4	5.6	18	68.9	17.2	29
9	0	100	6	16.7	83.3	6	0	100	6	0	100	11	90.9	9.1	11	83.3	16.7	6
10	21.7	69.6	23	20.8	75.0	24	4.2	87.5	24	8.1	89.2	37	100	--	24	64.2	25.0	28
11	0	83.3	6	0	100	6	16.7	66.7	6	8.3	91.7	12	100	--	12	46.4	21.4	28
12	28.6	57.1	7	60.0	40.0	5	50.0	50.0	6	83.3	16.7	12	100	--	6	66.7	16.7	6
13	38.5	61.5	26	50.0	50.0	26	28.0	72.0	25	55.9	44.1	34	100	--	14	88.9	11.1	18
14	0	76.9	13	0	91.7	12	0	100	13	25.0	70.8	24	100	--	23	100	--	6
15[a]	0	48.0	25	0	72.0	25	25.0	16.7	24	32.4	52.9	34	100	--	13	83.3	0	6
15[b]	0	82.5	40	4.0	86.0	50	2.0	78.0	50	0	82.7	52	96.7	3.3	30	87.5	6.3	32
16[a]	12.0	68.0	25	4.0	56.0	25	30.8	23.1	13	33.3	63.6	33	92.3	7.7	13	80.0	20.0	5
16[b]	0	62.5	24	4.3	69.6	23	0	66.7	12	0	95.7	23	100	--	6	88.9	0	18

[a] Mass culture.
[b] Monoconidial line from corresponding mass culture.
[c] Internal vascular discoloration only.

the mass cultures and the "b" cultures are a monoconidial line derived from the corresponding mass, as for example 7b derived from 7a. All the other cultures were derived from single spores.

That there were decided differences in the degree of virulence of the isolates would not be suspected from the results with the susceptible Porto Rico variety in Figure 2. However, isolates 7b, 9, 10, 11, 14, 15b, and 16b showed appreciably less pathogenicity for the resistant varieties than did isolates 6, 12, and 13. The monoconidial lines 7b, 15b, and 16b were less virulent than the corresponding mass cultures on Gold Rush and CaroGold, but monoconidial cultures, differing in virulence from the mass from which they came, can also be found in other wilt Fusaria.

The summary for varieties inoculated with either race 1 or race 2 shows decreasing resistance in the order of Tinian, B6313, Gold Rush, CaroGold, and Porto Rico (Figure 3). The Tinian variety was highly resistant since only an occasional plant was killed or stunted, and only single or a few leaves showed external symptoms of wilt. However, the fungus penetrated many plants when measured by vascular discoloration which was generally slight but in some instances extended 3 to 4 inches up the stem. The variety Porto Rico was highly susceptible; most of the plants were killed within 10 to 14 days after inoculation with highly virulent cultures.

The average percentages of wilt of a variety with all isolates of either race indicate that race 1 was somewhat more virulent than race 2 (Figure 3), but with a greater number of plants and fungus cultures this might not be true since some isolates of race 2 were similar in pathogenicity to some of race 1 (Figure 2).

Loss of Virulence in Culture: Hildebrand et al. (11) in a recent study of the sweetpotato wilt stated that, "The stock cultures should be transferred quarterly or at 3-month intervals for maintaining the cultures in a high state of virulence. The possibility of occurrence of significant variation within a single culture must be kept in mind although the probability may be low." These generalizations were drawn from work with 5 old stock cultures which were the residue of 40 that had been held for a decade or longer by the United States Department of Agriculture. In such a collection, which, over the years, seems to have been screened periodically for pathogenicity, one would expect to find some stable isolates that retained pathogenicity. It is interesting to note that their culture No. III, 7313a, and culture No. 6 in the present investigation, which was obtained as 7313b from the United States Department of Agriculture over 10 years ago, were apparently derived from the same collection. Isolate 7313b has remained highly virulent after routine transfers.

Variation in morphologic and physiologic characteristics commonly occurs when the wilt Fusaria are maintained in the laboratory by transferring them to potato-dextrose agar (PDA). Cultural variants in a monoconidial culture may appear at the first transfer (8) or at any other unpredictable time. Loss of virulence in early transfers of wilt Fusaria has also been observed many times by the writers. Complete or partial loss of virulence of sweetpotato isolates has also been reported by others (10, 15), although Hildebrand et al. (11) reported maintenance of virulence.

With very few exceptions, the monoconidial isolates in this study were derived from microspores. After the cultures had grown for some time on potato-dextrose agar, the tubes were capped with parafilm and as many as possible were stored in incubators at about 10° C, but, because of the large number in the collection, some were kept at room temperature in the light. Transfers of stock cultures have been made as infrequently as possible, usually about once a year, due to the apparent tendency of variants to occur when the cultures are kept in an active growing condition. Several transfers of the growth from the original single spore usually have been made. In subsequent transfers, the progeny transferred to one tube, for example, might show greatly reduced pathogenicity, but that to another tube might be as virulent as the original. A series of cultures from single spores from the first tube often contained a virulent one, but when those of reduced virulence were passed through the host several times no recovery of virulence was found. In the processes of heterokaryosis and parasexualism, once virulence is reduced or lost one might expect a regain of virulence to a very limited extent; however, the writers have never observed a case where this has occurred in several tests with many Fusaria.

Some of the variations in separate inoculations with isolate 1 are illustrated in Table 2. On 5-17-56 (column 1), the results with resistant varieties did not indicate a fungus with high virulence, although earlier tests indicated that this isolate was the most virulent of the race 1 cultures in the collection. On 6-1-56, the results agreed with those obtained earlier, that is,

Table 2. Results of inoculation of sweetpotato with Fusarium isolates which indicate changes in pathogenicity of the progeny of a single spore. (Isolate 1 in Table 1).

Variety	Inoculation on 5-17-56[a] column 1		Inoculation on 6-1-56[b] column 2		Inoculation on 11-29-56[c] column 3		Inoculation on 6-11-57[d] column 4			Inoculation on 6-11-57[e] column 5		
	Number of plants	Percent external wilt	Number of plants	Percent external wilt	Number of plants	Percent external wilt	Number of plants	Percent external wilt	Disease index[f]	Number of plants	Percent external wilt	Disease index[f]
Porto Rico	7	100	8	100	6	100	6	100	4.0	6	100	4.0
CaroGold	8	25.0	13	100	10	40.0	18	83.3	3.2	18	33.3	1.8
Gold Rush	5	0	6	100	10	20.0	20	50.0	1.9	17	11.8	1.4
B 6313	6	16.7	6	50.0	8	25.0	18	66.7	2.9	18	61.1	2.8
Tinian	6	33.3	6	100	--	--	19	36.8	1.8	19	21.0	1.5

[a] Low virulence of isolate. [b] high virulence of isolate. [c] low virulence of isolate.
[d] Isolate corresponding to one used on 6-1-56, high virulence.
[e] Isolate corresponding to one used on 11-29-56, low virulence.
[f] Disease index. Plant dead or nearly so = 4; external symptoms moderate = 3; external symptoms slight = 2; internal symptoms only (vascular discoloration) = 1; no symptoms = 0.

high virulence, but on 11-29-56 virulence was again low. A study of the temperature-humidity charts showed days in both of the first two experiments where the temperature was above 28° C, but these were not unusual, and various other inoculation tests in progress were not affected. In the test begun 11-29-56, the temperature was maintained at 28° C with only minor variations.

On the basis of past experiences these results suggested loss of virulence and tests were made to check this possibility. Since the original culture was used in the inoculations, another that had been transferred at the same time from the same tube as the original one had to be used in the subsequent tests. Two such cultures were selected, one corresponding to the one tested 6-1-56 which indicated high virulence (Table 2, column 2); the other corresponding to the one tested 11-29-56 which indicated low virulence (Table 2, column 3). Inoculations with both of these old cultures were on 6-11-57, and the results are given in columns 4 and 5 of Table 2. With one exception, the percentages of external wilt were somewhat less on the resistant varieties, but the relative rating of high virulence and low virulence was maintained. This is true of the data for percent of plants showing external symptoms of wilt or the disease index, which is more closely related to the over-all severity of disease. However, none of these changes in virulence would have been suspected if only the susceptible Porto Rico variety had been used.

Most of the isolates of race 2 have shown reduced pathogenicity on the Gold Dollar variety of flue-cured tobacco after various periods in culture, but this was not evident on the highly susceptible Porto Rico sweetpotato. Yet there are cultures of both races in the collection that are now nonpathogenic on this variety of sweetpotato, although they were highly pathogenic when first isolated.

CULTURAL CHARACTERS OF THE ISOLATES

Wollenweber (18) lists Fusarium batatatis Wr. and Fusarium hyperoxysporum Wr. as causing sweetpotato wilt. These were later (19) given as synonyms of Fusarium bulbigenum Cke. & Mass. var. batatas Wr. and F. oxysporum Schlecht. f. 2 Wr., respectively. McClure (13) separated 11 pathogenic cultures into two culturally distinct groups, which he believed to correspond to the two species and which "may also correspond to two of the three races listed as causing Fusarium wilt of tobacco." This interesting speculation was investigated in the early work on sweetpotato wilt.

Although the great variability of an Elegans Fusarium, as represented by the cotton-wilt fungus, was recognized (8), the 120 pathogenic isolates from sweetpotato and tobacco, representing races 1 and 2 which were available in 1945-46, provided abundant material for a more

extensive study of variability than had been made with the cotton fungus. Mass and monoconidial cultures were grown on a variety of media such as rice, potato plugs, plant stems, nutrient agar, and PDA; and numerous variants were also propagated, until there were about 2000 cultures. On the basis of cultural characters described by Wollenweber and Reinking (19), practically every species and form in the section Elegans was represented. Also, it was not difficult, on the basis of cultural appearances, to find the two species described by Wollenweber (18) as the cause of sweetpotato wilt. Single spore lines of the isolates which agreed closely with the description of F. hyperoxysporum and of F. batatatis were each grown in test tubes under uniform light conditions on a carefully prepared batch of PDA. Measurements of 200 of the 3-septate macroconidia of F. hyperoxysporum were in agreement with those given by Wollenweber (18). The measurements of the first 150 macroconidia from F. batatatis were also in agreement with his description of this species. However, 50 of the batatatis spores which were taken from the opposite side of a slant from which 50 had just been removed agreed in measurements with F. hyperoxysporum. Furthermore, the cultures of both species belonged to the same pathogenic race which showed that each race was not confined to a culturally distinct group (13).

One of the most striking variants was a highly pathogenic culture that had blue pigment in the mycelium, not simply a blue coloration in the medium or in the sclerotia. A culture of similar appearance also was found among pathogenic cotton isolates a few years later.

CROSS INOCULATIONS

Review of Literature

Johnson (12) gave the first clear description of Fusarium wilt of tobacco and named the causal fungus Fusarium oxysporum (Schlecht.) Wr. var. nicotianae J. Johnson. He made no cross inoculations of sweetpotato or cotton, but the fungus was probably a race of the cotton- or the sweetpotato-wilt Fusaria since a distinct tobacco-wilt Fusarium has not been found by later investigators. Johnson thought there was some relationship between the Irish potato and tobacco Fusaria but obtained no infection of tomato, cowpeas, and cabbage with the tobacco fungus. Harter and Weimer (10) found that the wilt Fusaria from sweetpotato and tomato were pathogenic only to the hosts from which they were isolated. Sweetpotato isolates did not cause wilt of Solanum melongena, S. tuberosum, Capsicum annuum, and Trifolium pratense. Smith and Shaw (15) reported that all wilt Fusaria from sweetpotato were pathogenic on burley tobacco, some on flue-cured tobacco, and none on cotton. Isolates from cotton were pathogenic on burley tobacco and cotton but slightly or not pathogenic on flue-cured tobacco. The Fusaria for these inoculations evidently were race 1 from cotton and races 1 and 2 from tobacco-sweetpotato. They found that tomato was not susceptible to an isolate from flue-cured tobacco, and that cotton, flue-cured tobacco, and sweetpotato were not susceptible to one from wilting cowpeas. Harter and Weimer (10) inoculated four species of morning glory and found that only Ipomoea hederacea became infected. McClure (13) inoculated sweetpotato, burley and flue-cured tobacco with sweetpotato isolates which caused wilt of all the hosts.

Everette (9) made extensive inoculations with 22 Fusarium isolates which were collected from wilted tobacco in Kentucky over a number of years. They were tested on a susceptible cotton, the Porto Rico sweetpotato, and nine varieties of tobacco; flue-cured, burley, one-sucker, and dark-fired types. At least 17 strains of Fusarium differing in pathogenicity seemed to be in the collection. Among them were four isolates[5] from tobacco that did not cause wilt of sweetpotato or cotton.

The investigation represents much work, but the results are difficult to evaluate for various reasons. 1) As there is no mention of monoconidial isolates, presumably all were mass cultures, but since several races of the wilt Fusaria attack tobacco, the possibility exists that a mass culture may be a mixed one. Furthermore, it has been shown (2) that both the sweetpotato and cotton-wilt Fusaria can be isolated from a wilting cotton plant, but the sweetpotato fungus did not cause wilt of cotton. Therefore, the use of mass cultures in cross inoculations may lead to erroneous conclusions. 2) The loss of pathogenicity for one host and not another commonly occurs with some of the wilt Fusaria after they have been kept on ordinary media in

[5] Two of these isolates were sent recently to the writers through the courtesy of G. A. Everette and G. W. Stokes. Evidently some factor in the original test prevented the appearance of external symptoms of disease, since each isolate killed 18 plants of Porto Rico sweetpotato when the usual inoculation procedures were used.

the laboratory. This has been noted in the present investigation and elsewhere (3, 6, 15). Unless the pathogenic potentialities of fresh cultures have been established and checked in succeeding experiments, the determination of races of the wilt Fusaria will be greatly confused. Therefore, the testing of a set of differential hosts preferably should be done concurrently with an inoculum of known pathogenicity. With old cultures and a variety of hosts of varying degrees of resistance there may be as many strains or races as there are cultures. 3) The experiments were performed at 33° C. Since this is near the maximum temperature for wilt development, variations of a few degrees above this temperature could have prevented the appearance of external symptoms.

Experiments by the Writers

Porto Rico sweetpotato was inoculated also with other wilt Fusaria of recently proved pathogenicity. None of the isolates from the following hosts produced external symptoms of wilt: alfalfa; asparagus; aster; bean; beet; cabbage races 1, 2, and 3; carnation; Cassia tora; celery; cotton from United States races 1 and 2, cotton from India, cotton from Egypt; cowpea races 1 and 2; cucumber; mimosa race 1; muskmelon; pea races 1 and 2; sesame; spinach; sumac; tomato races 1 and 2; and watermelon.

No wilting occurred when the following plants were inoculated with isolates of either race or both races of the sweetpotato wilt Fusarium used separately: Kansas Common alfalfa; Mexican pink bean; Heavenly Blue aster; Sugar Beet G. W. 359; Copenhagen Market cabbage; Orion carnation; Cassia tora; Golden Self-blanching celery; Rowden, Sakel, and Ashmouni cottons; Lady Finger and California Black-eye 5 cowpeas; Palmetto cucumber; mimosa (Albizzia julibrissin); Hale's Best muskmelon; Clemson Spineless okra; Thomas Laxton pea; Long White Icicle radish; Criollo sesame; Yelredo soybean; Bloomsdale Savoy spinach; Ten-weeks bright pink stock; sumac (Rhus typhina); pure white sweet william; Bonny Best tomato; and Garrison watermelon.

HOST RELATIONSHIPS

According to Wollenweber and Reinking (19), Fusarium bulbigenum Cke. & Mass. var. batatas Wr. and Fusarium oxysporum Schlecht. f. 2 Wr. cause wilt of sweetpotato and Fusarium oxysporum Schlecht. var. nicotianae J. Johnson causes wilt of tobacco. Snyder and Hansen (16) use Fusarium oxysporum f. batatas (Wr.) Snyd. & Hans. and F. oxysporum f. nicotianae (J. Johnson) Snyd. & Hans. for the sweetpotato and tobacco organisms, respectively.

The complexity of the host relations of the wilt Fusaria is shown by the sweetpotato races 1 and 2. Both races cause wilt of a susceptible burley tobacco, and so do the two races of the U. S. cotton Fusarium (6). However, the races of the sweetpotato fungus do not cause wilt of cotton, nor do the cotton races cause wilt of sweetpotato. Race 2 of the sweetpotato Fusarium and race 2 of the cotton Fusarium cause wilt of a susceptible flue-cured tobacco. The latter also causes wilt of Yelredo soybean, and so does race 1 of the cowpea Fusarium (3); but race 1 of the cowpea fungus will not cause wilt of cotton, tobacco, or sweetpotato. Both races of the cotton fungus also cause wilt of alfalfa (5), but the alfalfa wilt Fusarium does not cause wilt of cotton, tobacco, or Yelredo soybean. From wilting burley tobacco, isolates of wilt Fusaria have been obtained that, upon testing with the proper hosts, could be classified under the Snyder and Hansen system not only as forma nicotianae, but also batatas, vasinfectum, medicaginis, and tracheiphilum. The last two are included since vasinfectum wilts alfalfa and also Yelredo soybean, which is susceptible to a race of the cowpea wilt Fusarium.

Isolates from American upland cotton likewise might be vasinfectum, nicotianae, medicaginis, tracheiphilum, and the unnamed one affecting Cassia tora. The complexities of the host relationships of the American, Indian, and Egyptian cotton-wilt Fusaria have been indicated (4), and when these are presented in greater detail, perhaps the proper designation of these pathogenic entities of the wilt Fusaria can be considered.

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SCREENING OF POTATO FUNGICIDES IN 1958[1]

L. C. Callbeck[2]

Ten fungicides for potato late blight (Phytophthora infestans (Mont.) de Bary) were included in the 1958 Screening Test of the Science Service Laboratory at Charlottetown, Prince Edward Island. These fungicides were:

1. Blitane -- Containing 37 percent copper from copper oxychloride and 16 percent zineb.
   Concentrations: (a) 2 pounds per 80 Imperial gallons and, (b) 3-80.
   Source: Fisons Pest Control Limited, Cambridge, England, and received through International Fertilizers Limited, Quebec, Quebec.

2. Chem-Bam -- Nabam.
   Concentration: 2 quarts + 1 pound zinc sulfate-80.
   Source: Chemical Insecticide Corporation, Metuchen, New Jersey, and received through Canada Packers, Charlottetown.

3. Charlottetown experimental mixture -- A 3-to-1 mixture of maneb and copper oxychloride sulfate and containing a small portion of zinc sulfate.
   Concentration: 1.75-80.

4. Dithane M-22 -- Maneb.
   Concentrations: (a) 1-80, (b) 1.5-80.
   Source: Rohm and Haas Company.

5. Dyrene 50-W -- 2,4-Dichloro-6-(o-chloroanilino) -s-triazine.
   Concentration: 1.5-80.
   Source: Chemagro Corporation, and received through Green Cross Products, Montreal, Quebec.

6. LO-1499 -- Ammonium ethylene bisdithiocarbamate.
   Concentration: 1 quart + 1 pound zinc sulfate-80.
   Source: Rohm and Haas Company.

7. Manzate -- Maneb.
   Concentration: 1.5-80.
   Source: DuPont Company of Canada Limited, Montreal, Quebec.

8. Mercurized Copper Oxychloride -- 50 percent copper, 0.6 percent mercury as phenyl mercury chloride.
   Concentration: 2.5-80.
   Source: F. W. Berk and Company Limited, London, England, and received through Green Cross Products.

9. 03818-B -- Nickel ethylene bisdithiocarbamate and zineb.
   Concentration: 3.5-80.
   Source: Rohm and Haas Company.

10. Perenox -- Cuprous oxide.
    Concentrations: (a) 1.5-80, (b) 4-80.
    Source: Plant Protection Limited, England; supplied by Chipman Chemicals Limited, Hamilton, Ontario.

Bordeaux mixture, 8-4-80, as in all previous years, as the standard fungicide, and an unsprayed control were included. There were fifteen sets of plots in all.

The plots were planted on June 5, and the Green Mountain seed pieces were counted to

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[1]Contribution No. 1730 from the Botany and Plant Pathology Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario.

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assure the same number in each row. Each plot was 4 rows wide by 50 feet long; and fifteen plots, one for each treatment, were planted in each of five ranges. Single rows of potatoes were used as borders and buffers, and, because these rows were not sprayed, they served as sources of late blight infection. All data were taken from the two center rows.

The sprays were applied with an experimental tractor-sprayer unit, custom built for the work. The nozzles were so placed on the boom that each row received a 4-nozzle spray, and the fungicides were delivered at a pressure of 375 pounds per square inch. All rows were sprayed with DDT on July 11 and with Malathion on August 4. The fungicides were applied July 18, 28, August 6, 15, 28, September 4.

Late blight appeared naturally in a buffer row on July 18, -- the earliest it has ever been recorded in our plot area -- and spread quickly over the field. By August 27 the unsprayed check plots were 70 percent defoliated and defoliations in the treated plots ranged from a trace for LO-1499 to 6 percent for Dyrene. At this time a period of rainy weather occurred which delayed spray operations and favored a very rapid development of the epidemic. It had been planned to spray at least every 10 days, and as the fourth application had been given on August 15, the fifth should have fallen on Monday, August 25. However, it rained from Sunday to Wednesday, the amounts in inches being 0.13, 1.70, 0.80, 0.04, for a total of 2.67. Because of these wet days, the fifth spray was not applied until August 28, an interval of 13 days. The mean relative humidity for the period of August 25-29 was 84.1 percent, and this humidity, with the precipitation and the delay in making the fifth application, allowed the disease to become very severe. The check plots were 100 percent defoliated by September 3, at which time great differences in the performance of the fungicides became apparent. From August 27 to September 3 the plots treated with Dyrene increased from 6 percent defoliation to 86 percent; Chem-Bam from 2 percent to 68 percent; Perenox (1 1/2-80) from 4 percent to 77 percent. The best materials during these severe conditions were Bordeaux, LO-1499, Mercurized Copper Oxychloride, Manzate, Dithane M-22, 03818-B, Charlottetown mixture.

Defoliation readings were taken at regular intervals, and the mean defoliation for selected dates, expressed as percentages, is given in Table 1.

Table 1. Percentage defoliation caused by late blight.

Treatment	Aug. 27	Sept. 3	Sept. 10	Sept. 15
Blitane (2 pounds)	2.0	31	87	97
Blitane (3 pounds)	1.0	17	60	82
Bordeaux	1.0	10	30	40
Chem-Bam	2.0	68	95	97
Ch'town Mixture	0.5	14	57	77
Dithane M-22 (1 pound)	1.0	15	78	93
Dithane M-22 (1.5 pounds)	0.5	12	43	60
Dyrene 50-W	6.0	86	100	--
LO-1499	Trace	11	53	60
Manzate	0.5	10	42	53
Mercurized Copper	1.0	11	54	70
03818-B	1.0	12	60	76
Perenox (1.5 pounds)	4.0	77	100	--
Perenox (4 pounds)	2.0	38	88	97
Check	70.0	100	--	--

Chem-Bam, Dyrene, and Perenox (1.5-80) were withdrawn from the applications made on September 4 because the plots sprayed with these fungicides were already severely defoliated and most of the remaining green leaves bore small lesions.

On September 16, or 103 days after planting, the plots that had not been killed by disease were sprayed with Liquid Cyanamid to destroy the remaining foliage. At the end of the month the tubers were lifted, graded, weighed, and examined for late blight rot. The results are presented in Table 2.

Table 2. Effect of treatments on yield and on late blight tuber rot.

Treatment	Total Bu/A	Smalls Bu/A	Rot Bu/A	No. 1 Bu/A	Percent rot
Blitane (2 pounds)	407.6	94.6	29.2	283.8	7.2
Blitane (3 pounds)	408.4	93.7	8.9	305.8	2.2
Bordeaux	417.8	82.1	5.3	333.4	1.3
Chem-Bam	360.6	82.3	25.3	253.0	7.0
Ch'town Mixture	404.5	77.9	5.8	320.8	1.4
Dithane M-22 (1 pound)	407.3	80.1	16.1	311.1	4.0
Dithane M-22 (1.5 pounds)	421.7	74.4	8.5	338.8	2.0
Dyrene 50-W	379.9	86.0	31.7	262.2	8.3
LO-1499	427.4	73.9	2.8	350.7	0.7
Manzate	429.4	83.2	6.1	340.1	1.4
Mercurized Copper	399.7	88.4	15.2	296.1	3.8
03818-B	415.1	75.2	25.7	314.2	6.2
Perenox (1.5 pounds)	370.7	101.6	27.5	241.6	7.4
Perenox (4 pounds)	376.6	99.0	15.8	261.8	4.2
Check	299.3	93.0	52.4	153.6	17.5
S. D. 5%	37.2			48.8	5.4
S. D. 1%	49.5			64.9	7.1

SCIENCE SERVICE, CANADA DEPARTMENT OF AGRICULTURE

CUCUMBER FUNGICIDE TESTING ON THE WEST COAST OF FLORIDA[1]

Grover Sowell, Jr.[2]

Summary

Nabam + $ZnSO_4$ has consistently given excellent control of downy mildew, caused by Pseudoperonospora cubensis (Berk. & Curt.) Rostow., and plants sprayed with this fungicide have produced the highest yield of marketable cucumbers. Zineb was equal to nabam + $ZnSO_4$ in downy mildew control but reduced the yield during one season. Maneb and nabam + $MnSO_4$ also caused yield reductions. Thiram gave excellent control of soil rot caused by Rhizoctonia solani Kuehn, anthracnose caused by Colletotrichum lagenarium (Pass.) Ell. & Halst., and cottony leak caused by Pythium aphanidermatum (Edson) Fitz. Ferbam partially controlled soil rot. Captan, maneb and nabam + $MnSO_4$ gave excellent control of anthracnose. Ferbam, captan, and zineb + neutral copper partially controlled cottony leak.

INTRODUCTION

The literature on cucumber fungicide testing in the southeastern United States has been reviewed, and the results of two seasons of fungicide testing in the west coast area of Florida have been reported by Sowell (5). The following article concerns further cucumber fungicide tests conducted at the Gulf Coast Experiment Station, Bradenton, Florida.

MATERIALS AND METHODS

Cucumbers of the variety Marketer were used in these tests. The plots were 20 feet long by 1 row wide and were bordered on both sides by unsprayed guard rows. The experimental design was a randomized block with four replications. The fungicides were applied with a John Bean portable pumping unit equipped with a by-pass agitator and mounted on a tractor-drawn trailer. Ten-gallon milk cans were used as containers for the fungicides. Approximately 50 to 200 gallons per acre of liquid were applied to the plants, depending on their age. Pressure varied from 300 to 400 pounds per square inch at the pump. Parathion was added to all treatments as needed for insect control.

The incidence of downy mildew was evaluated by using the grading system proposed by Horsfall and Barratt (2). Control of anthracnose, soil rot, and cottony leak was evaluated by determining the percentage of fruit infected and converting the data to angles as suggested by Snedecor (3) before statistical analyses were conducted.

1956 Fall Test: The experimental field was planted on September 14. On October 10 maneb was applied to the entire planting, since downy mildew was present on the plants and the test plots had not yet been staked out. The coined and/or chemical name and the amount and name of the trade material used per 100 gallons of water for each of the fungicides used in this test were as follows[3]: nabam + $ZnSO_4$, 2 quarts Dithane D-14 (19 percent disodium ethylene bis [dithiocarbamate]) + 0.75 pound (36 percent $ZnSO_4$); zineb, 2 pounds Parzate (65 percent zinc ethylene bis [dithiocarbamate]); nabam + $MnSO_4$, 2 quarts Dithane D-14 + 1 pound Techmangam (75 percent $MnSO_4$); maneb, 2 quarts Dithane M-22 (70 percent manganous ethylene bis [dithiocarbamate]); zineb + basic copper sulfate, 2 pounds Parzate + 3 pounds Tennessee Tribasic Copper Sulfate (53 percent metallic copper); manganese carbamate, 2 pounds Tennam; 2,4-dichloro-6-(o-chloroanilino)-S-triazine, 2 pounds Dyrene; captan, 2 pounds Or-

[1] This research was aided by a grant from the Tennessee Corporation.

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[3] All of the fungicides used in these tests were supplied without cost by the manufacturers.

thocide 50W (50 percent N-(trichloromethylthio)-4 cyclohexane-1,2-dicarboximide). Applications of the fungicides were made twice weekly. A single, heavy application of captan, (treatment 6) was applied to the plants at the rate of 16 pounds Orthocide 50W per 100 gallons and 200 gallons per acre when the first flowers appeared on the plants. 50 ppm Gibberellin (treatment 7) was applied after the fourth picking. A total of seven pickings were made.

1957 Spring Test: The experimental field was planted on March 15. In treatments 1-6, the plots received the same fungicide throughout the crop season. In treatments 7-11, two fungicides were alternated. Treatments 12-14 received zineb twice weekly and special treatments to control soil rot (treatments 12 and 13), angular leaf spot (treatments 11 and 13), and powdery mildew (treatment 14). The coined and/or chemical name and the name and amount of the trade material used per 100 gallons of water for each of the fungicides used in this test were as follows: zineb, 2 pounds Parzate; maneb, 1.5 pounds Manzate (70 percent manganous ethylene bis [dithiocarbamate]); nabam + $ZnSO_4$, 2 quarts Dithane D-14 + 0.75 pound of 36 percent $ZnSO_4$; captan, 4 pounds Orthocide 50W in treatment 9, 16 pounds Orthocide 50W in treatments 12 and 13; zineb + basic copper sulfate, 2 pounds Parzate + 3 pounds Tennessee Tribasic Copper Sulfate; ferbam, 4 pounds Fermate (76 percent ferric dimethyldithiocarbamate); chloranil, 2 pounds Spergon (48 percent tetrachloro-p-benzoquinone); zineb + basic copper sulfate, 2 pounds Parzate + 3 pounds Tennessee Tribasic Copper Sulfate; basic copper sulfate + streptomycin, 4 pounds Tennessee Tribasic Copper Sulfate + 100 ppm streptomycin as Agristrep; basic copper sulfate, 4 pounds Tennessee Tribasic Copper Sulfate; dinitro-capryl phenyl crotonate, 0.5 pound Karathane; N-(trichloromethylthio) phthalimide, 4 pounds Phaltan. Foliage applications were made approximately twice weekly. Treatment 8 received zineb instead of Phaltan in one application and the copper was omitted from treatment 14 in two applications. A special application to control soil rot, consisting of 200 gallons per acre of a spray containing 16 pounds of captan per 100 gallons was made to the plants of treatment 9 after the first flowers appeared on the plants and to the plants of treatment 10 after the first harvest.

RESULTS

1956 Fall Test: Highest yields of marketable cucumbers and excellent control of downy mildew were obtained with zineb, maneb + gibberellin, nabam + $ZnSO_4$, and maneb alternating with captan (Table 1). Maneb, nabam + $MnSO_4$ and maneb plus a heavy application of captan

Table 1. Yield of marketable fruit and incidence of downy mildew in the 1956 fall cucumber fungicide trial.

Treatment number	Twice-weekly foliage treatment	Other treatments (single application)	Yield (pounds per plot)	Incidence of downy mildew[a]
1	Nabam + $ZnSO_4$		176.0	4
2	Zineb		177.7	4
3	Nabam + $MnSO_4$		132.8	4
4	Maneb		153.1	4
5	Zineb + basic copper sulfate		115.6	9
6	Maneb	Captan at blooming	148.1	5
7	Maneb	Gibberellin	175.4	4
8	Maneb alternating with captan		155.2	4
9	No Fungicide		43.3	40
10	Tennam[b]		82.6	23
11	Dyrene[c]		132.2	18
LSD .05			23.2	2.6
LSD .01			31.2	3.5

[a]The plots were graded 1-10 as suggested by Horsfall and Barratt (1), and the data presented represent the total grade of the four replications.
[b]Manganese carbamate manufactured by Tennessee Corporation.
[c]50 percent 2,4-dichloro-6-(o-chloroanilino)-S. triazine.

were inferior to zineb with respect to yield. The yield and downy mildew control of plants sprayed with zineb + basic copper sulfate, Dyrene, and Tennam were inferior to zineb used alone. Unsprayed plants were completely defoliated before the last harvest, and no cucumbers were picked from these plants at the last two harvest dates.

1957 Spring Test: An alternating schedule of nabam + $ZnSO_4$ and nabam + $MnSO_4$ resulted in the highest yield of marketable cucumbers in this trial (Table 2). Although plants sprayed with maneb + thiram yielded equally as well as did those sprayed with the above schedule, the yield of maneb-sprayed plants was inferior to that of plants given either of these treatments. The yield difference between plots sprayed with maneb alone and those sprayed with maneb +

Table 2. Yield of marketable fruit and incidence of three cucumber diseases in the 1957 spring cucumber fungicide trial.

Treatment number	Treatment	Yield (in pounds)	Percentage of infected fruit[a]		
			Soil rot	Anthracnose	Cottony leak
	Thirteen applications of same fungicide				
1	Zineb	117.0	38	31	6
2	Maneb	97	34	16	3
3	Nabam + $ZnSO_4$	146	34	19	8
4	Zineb + basic copper sulfate[b]	100	31	31	3
5	Maneb + thiram	163	11**[c]	2**	0**
6	Captan	124	28	8*	2
	Thirteen applications of alternating materials				
7	Zineb - Maneb	100	33	12	7
8	Nabam + $ZnSO_4$ - nabam + $MnSO_4$	168	31	8	8
9	Zineb - captan	124	43	10	9
10	Zineb - ferbam	117	13**	28	2*
11	Zineb - chloranil + 1 application of basic copper sulfate [d]	83	45	31	11
	Thirteen applications of zineb +				
12	1 application of captan after first flowering	128	28	12	7
13	1 application of captan after first picking plus 1 application of basic copper sulfate + streptomycin later	95	43	25	15
14	2 applications of Karathane	100	43	25	11
15	No fungicide	26	16*	22	3
LSD .05		30			
LSD .01		63			

[a]Yield is expressed as pounds of marketable fruit per four replications (1/244 acre).

[b]An extra application of this treatment was made when the other special angular leaf spot treatments were applied.

[c]The standards of comparison for determining the statistical significance of the differences were the no fungicide plots in the case of yield and the nabam + $ZnSO_4$ plots in the case of fruit infection. Single and double asterisks mean that the difference between the indicated percentage and that of the standard of comparison is significant at the .05 or .01 level of statistical significance, respectively.

[d]A single application of basic copper sulfate (4-100) was made for control of angular leaf spot. These plots received only zineb before first fruit set.

thiram may be explained by the low incidence of all three fruit-decaying fungi in plots sprayed with the combination. From the standpoint of yield, nabam + $ZnSO_4$ was equal to the best treatments. All of the remaining materials were inferior to nabam + $ZnSO_4$ alternating with nabam + $MnSO_4$ or to maneb + thiram in this respect. The unsprayed check plants were defoliated before the last harvest, and the relatively dry environment of the soil surface in these plots apparently was responsible for the low incidence of soil rot and cottony leak. Consequently, in the evaluation of the control of fruit diseases obtained in this experiment, the nabam + $ZnSO_4$ plots were used as the standard of comparison or "check". Soil rot and cottony leak were not as prevalent in the plots sprayed with an alternating schedule of ferbam and zineb as they were in the check plots (Table 2). Other fungicides, including the formerly effective captan treatments, were ineffective this season in the control of soil rot. All of the manganese carbamate and captan treatments, except the heavy application of captan after the first harvest, were superior to zineb in the control of anthracnose, whether they were used exclusively or alternated with a zinc-carbamate.

DISCUSSION

The results of these tests agree with previous fungicide trials conducted at the Gulf Coast Experiment Station in showing that nabam + $ZnSO_4$, zineb, nabam + $MnSO_4$, and maneb are all highly effective against downy mildew of cucumbers. The low yield of plants sprayed with nabam + $MnSO_4$ or maneb is difficult to understand in view of the excellent performance of maneb in tests conducted by Wilson and Swank (6) and by Epps (1). It appears, however, that the evidence is strong enough to recommend that the manganese carbamate fungicides not be used on cucumbers in the west coast area of Florida. Zineb has also caused a statistically significant reduction in yield when compared with nabam + $ZnSO_4$ (5). In the 1957 trial, the difference between yield of plots sprayed with zineb or with nabam + $ZnSO_4$ was just 0.7 pounds less than that required for statistical significance at the 5 percent level. Although no definite conclusion can be drawn from this rather inconsistent result, the author considers that the evidence indicates that nabam + $ZnSO_4$ is the least phytotoxic to cucumbers of all the carbamate fungicides. Since this fungicide will give excellent control of downy mildew, it is believed that nabam + $ZnSO_4$ should be the preferred fungicide for use on cucumbers.

Soil rot has been controlled during certain seasons by applications of basic copper sulfate and of captan (4, 5). The inconsistency of the results, however, prevents the recommendation of any material for grower use against soil rot. The effectiveness of ferbam in partially controlling this disease in the 1957 test indicates that this fungicide deserves further attention in future tests. Thiram appears to have a wide spectrum of effectiveness when mixed with maneb, since this was the most effective treatment against soil rot, anthracnose, and cottony leak in the 1957 test.

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GULF COAST EXPERIMENT STATION, BRADENTON, FLORIDA

TWO NEW PICKLING CUCUMBER VARIETIES RESISTANT TO SCAB AND MOSAIC[1]

J. C. Walker

The Wisconsin Experiment Station in cooperation with the Wisconsin Pickle Packers' Association has continued the pickle cucumber breeding program which has already yielded the varieties Wisconsin SR 6 and Wisconsin SR 10 (3), resistant to scab (incited by Cladosporium cucumerinum Ell. & Arth.), and Wisconsin SMR 9 and Wisconsin SMR 12 (2), resistant to scab and to mosaic (incited by cucumber mosaic virus). It was recognized when the last two varieties were released to seed growers early in 1954 that, although they were highly resistant to both diseases, there was still room for improvement in fruit and vine characteristics. The basic stock from which Wisconsin SMR 9 and 12 were derived was crossed and backcrossed to Ohio MR 17 (4) and Ohio MR 25 (5), respectively. Each backcross progeny was assayed for scab resistance according to the method previously described (1). Since both parents in each cross were highly resistant to mosaic, selection for this type of resistance was unnecessary. When the desired plant characters were approached by backcrossing, two successive self generations were assayed for scab resistance and several progenies from each cross homozygous for resistance to scab and highly resistant to mosaic were evaluated as to yield, green-stock quality, and salting potentiality. A progeny from each cross was finally selected for increase. Evaluation trials of the increase lots were conducted at Madison, Wisconsin in 1955, 1956, and 1957. The line selected from the original cross with Ohio MR 25 was named Wisconsin SMR 15; that from the cross with Ohio MR 17 was named Wisconsin SMR 18. Foundation stock seed of each variety was released to primary growers of cucumber seed early in 1958. Seed becomes available through retail and wholesale channels for use in the spring of 1959.

EVALUATION TRIALS

The new varieties were tested repeatedly for resistance to scab by the greenhouse method (1) and were found to be homozygous for that character when released. Similarly, field tests for mosaic resistance were conducted in which seedlings were inoculated soon after emergence with a severe strain of cucumber mosaic virus. Since the mosaic resistance concerned here does not preclude multiplication of the virus in the host, the evaluation of resistance was based on percentage of severely mottled fruits. The results of trials in 1956 and 1958, presented in Table 1, show that severely mottled fruits were absent or negligible in amount in the four resistant varieties Wisconsin SMR 12, 15, and 18, and Ohio MR 17, while in the two susceptible varieties, Wisconsin SR 6 and National Pickling, 25 percent or more of the fruits were so affected.

The data from yield trials of the two new varieties in comparison with Wisconsin SMR 12 and Ohio MR 17 at Madison, Wisconsin are presented in Table 2.

The important characteristics of the new varieties are presented below.

Major Characteristics of Wisconsin SMR 15: The vine is similar to Wisconsin SMR 12 in color, but is thicker in stem and leaves are somewhat larger. Fruit begins to appear about the same time as in SMR 12 but numbers of female flowers may be lower in the first part of the fruiting period. Color of fresh fruit is slightly darker than SMR 12 (which is sometimes objectionably light in color) but is well within the range of National Pickling, Chicago Pickling, and Wisconsin SR 6. The fruit is blocky like National Pickling and quite free from tapering to the blossom end as in Wisconsin SMR 12. The length-diameter ratio is equivalent to that of SR 6 and slightly lower than that of SMR 12. The fruit is firmer in both green and salt stock than that of Wisconsin SMR 12, as determined by pressure test, and the texture of the seed cavity is superior. The yield capacity is slightly lower than that of SMR 12 and about equivalent to that of Ohio MR 17 at Madison.

[1] Published with the approval of the Director of the Wisconsin Experiment Station. In the course of this work the writer has had the able assistance of C. F. Pierson, J. B. Sinclair, S. D. Van Gundy, and S. L. Wasuwat. The investigation was supported in part by a grant from the Wisconsin Pickle Packers' Association.

Table 1. Incidence of severely mottled fruits in plants inoculated in the field in the early seedling stage with cucumber mosaic virus; Madison, Wisconsin.

Variety	1956		1958	
	Total number of fruits	Percent mottled	Total number of fruits	Percent mottled
National Pickling			124	35
Wis. SR 6	78	26		
Wis. SMR 12	93	0	721	1
Wis. SMR 15	131	0	653	1
Wis. SMR 18	104	0	872	0
Ohio MR 17	71	0		

Table 2. Yield and fruit measurements of cucumber varieties Wisconsin SMR 12, Wisconsin SMR 15, Wisconsin SMR 18, and Ohio MR 17; Madison, Wisconsin.

Variety	Yield[a] (bushels per acre)	Length-diameter ratio[b]	Pressure reading[b, c]	
			1 3/8 inch fruit	1 3/4 inch fruit
Wis. SMR 12	344	2.97	16.3	17.7
Wis. SMR 15	302	2.88	17.8	19.7
Wis. SMR 18	363	3.08	18.4	20.2
Ohio MR 17	314	3.24	18.4	19.5

[a] Average of values for 1955, 1956, and 1957.
[b] Average of values for 1956 and 1957.
[c] Determined on green fruits with standard fruit pressure tester with 5/16 inch tip.

Major Characteristics of Wisconsin SMR 18: The vine is somewhat thicker in stem and darker green in color than that of Wisconsin SMR 12. Fruits begin to appear at the same time as with SMR 12 and yields are consistently equal to or above the latter. The fresh fruit is deeper green than that of SMR 12 or 15 and closely resembles that of Ohio MR 17. The fruits are equal to those of SMR 15 and distinctly superior to those of SMR 12 in lack of taper at the blossom end. The length-diameter ratio is consistently higher than that of SMR 12 and approximately midway between the latter and Ohio MR 17. The fruit is about equal to SMR 15 in firmness in the green and salt stock and thus superior to SMR 12. The internal structure in salt stock is distinctly above that of SMR 12 and close to that of SMR 15.

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WISCONSIN EXPERIMENT STATION, MADISON

STATISTICAL TECHNIQUE IN INDEXING LETTUCE SEED FOR MOSAIC CONTENT[1]

Henry Tucker and Robert E. Foster[2]

Common mosaic, Marmor lactucae Holmes, is a potentially serious disease of lettuce in all areas of the Southwest. The disease is seed-borne with about 1 to 4 percent of the seed infected in most ordinary lettuce stocks. Infected seedlings serve as a primary source of inoculum; secondary infection leading to severe losses occurs through activity of the aphid vector. Severity of the disease at plant maturity depends largely upon insect population and insect movement following the planting of ordinary infected seed.

The most effective control for this disease is the use of seed virtually free of seed-borne infection. For a practical degree of control, no more than 0.1 percent of all the seed may carry the virus (2, 3).

Several seed companies are producing lettuce seed to contain 0.1 percent or less mosaic infected seed. Seedling tests have been devised to reveal infected individuals within large populations. These tests must be accurate to prevent mislabeling and its consequent penalty under existing seed laws.

Previously, the practice in indexing seed for mosaic content has been to examine from 3000 to 20,000 seedlings, note the number of infected plants, and then calculate the percent infected by the formula: (number infected ÷ number examined) x 100 = percent infected. Thus, if 9 infected seedlings were discovered in an examined sample of 10,000 plants, the calculated percentage would be 0.09 percent. The sample would then be judged to fall within the necessary limits (0.1 percent or less) and the bulk lot of seed from which the sample had been drawn would be so labeled. If, in this same sample, 11 infected plants were noted, the calculated percentage would be 0.11 percent and the lot could not qualify for the desired label. Samples with 10 infected seedlings were held for further checking.

If a lot of seed with exactly 0.1 percent infected seed were examined by taking successive random samples of 10,000 each until the entire lot was exhausted, it would be observed that the greatest percentage of samples would contain 10 infected seeds. A somewhat smaller percentage of the samples would contain 9 or 11 infected seeds. Many fewer samples would contain less than 5 or more than 15 infected seeds. This distribution of samples follows a known mathematical curve, which enables us to determine in advance what proportion of the samples taken would be expected to contain a given number of infected seed in a given sample size or the probability of obtaining a single sample with a given number of infected seeds (1). For example, in a lot 0.1 percent defective about 30 percent of the samples taken would have 11 or more infected seeds in 10,000 and about 45 percent of the samples would have 9 or fewer infected seeds in 10,000. Since, in practice, we do not know the percent of infected seed in the lot we can only estimate, with a given degree of reliability, the upper limit of the percent infected seed in a lot based on a single sample, or estimate the reliability we can place in the lot having less than a specified percent infected seed. In the above indexing procedure, where a lot is accepted if 9 infected seeds are found in a sample of 10,000, only 69 percent confidence can be attached to the conclusion that the lot contains no more than 0.1 percent infected seed. This is considerably less than the confidence required for acceptance of most biological or industrial materials where 95 or 99 percent is usually used, and suggests that a considerable number of seed lots may be mislabeled by such procedures. In order to get greater confidence, it is necessary to set the "accept-reject" point much lower than the calculated percentage figure would indicate.

In Table 1 are given the confidence levels which can be applied to the statement, "this seed contains 0.1 percent or less seed-borne mosaic infection," when various numbers of infected individuals are found in various size samples. This table may be used in the following manner: Decide in advance what level of confidence is desired and determine what size sample can be examined. Enter the table at the row for the sample size desired and move to the right until the desired confidence level is reached ;then read up the column. The figure given at the top will be the maximum number of infected individuals that can be tolerated. Reject, as not meeting the requirements stated above, all samples showing a larger number of mosaic infected seedlings.

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[1]Arizona Agricultural Experiment Station Technical Paper No. 496.

[2]Statistician and Horticulturist, respectively, Agricultural Experiment Station, University of Arizona.

Table 1. Levels of confidence in mosaic index tests.

Sample Size (Thousands)	Number of Infected Individuals [a]																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
3		97.9	85.5	61.4																	
4			96.2	80.8	59.9																
5			99.3	92.5	77.3	58.7															
6				97.8	89.4	74.9	57.9														
7				99.5	96.0	86.8	72.9	57.5													
8					98.8	94.1	84.6	71.5	57.0												
9					99.7	97.8	92.3	82.7	70.2	56.5											
10					99.3	96.7	90.1	81.2	69.1	56.0											
12					98.8	98.1	89.2	87.8	78.5	67.4	55.6										
14						99.8	98.9	96.6	92.2	85.5	76.4	66.0	55.2								
16							99.9	99.4	98.0	95.2	90.3	83.4	74.6	65.0	54.9						
18								99.9	99.6	98.8	97.0	93.6	88.5	81.7	73.6	64.2	54.6				
20									99.8	99.3	98.1	95.8	92.2	87.1	80.2	72.2	63.4	54.4			

Greater than 99.9 percent

Less than 50 percent

[a] Since the number of infected individuals is an integer, fractional values are never obtained. However, the interval X ± .5 may be regarded as the true range of values which would be regarded as containing X individuals. This principle was followed in computing estimates in this table.

Tests involving large samples can be divided at the beginning into portions corresponding to smaller sample units given in the table. Then if, upon examination of one portion, the indicated "accept" level of infected individuals has not been exceeded, the sample may be judged acceptable without further examination of the remaining population. For example, if the test is set up with a single total sample of 10,000 and a desired confidence level of 95 percent, the maximum number of infected individuals that can be tolerated is 6. If, however, plantings are made of 4000, 4000 and 2000 seedlings and then the first group is found to contain only 2 mosaic infected plants, there would be no need of examining the other 6000 seedlings. If 3 infected seedlings were found in the first 4000 examined but only 1 in the second 4000 group for a total of 4 infected in 8000 the lot may be accepted without examining the remaining 2000.

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ARIZONA AGRICULTURAL EXPERIMENT STATION, MESA, ARIZONA

OCCURRENCE OF ASTER YELLOWS ON CLOVERS IN CALIFORNIA[1]

P. M. Halisky, J. H. Freitag, B. R. Houston, and A. R. Magie[2]

Abstract

A study was made on the effect of aster-yellows virus in clovers. Natural infection in the field has recurred in Ladino white clover (Trifolium repens), red clover (Trifolium pratense), and alsike clover (Trifolium hybridum) in California. The virus was recovered by aster leafhoppers (Macrosteles fascifrons) from naturally infected clovers and transmitted to Nicotiana rustica, Plantago major, Vinca rosea, celery, and aster. Ladino, alsike, and red clover plants were experimentally infected with aster yellows by leafhoppers for a comparative study of host response. The external symptoms and internal anatomical changes associated with aster yellows infection in clovers are discussed.

The natural occurrence of aster yellows on clovers in California has been observed on several occasions. In an early study of the weed host range of the California aster-yellows virus Frazier and Severin (1) listed three leguminous plants as hosts: bur clover (Medicago hispida), white sweetclover (Melilotus alba), and trefoil (Lotus salsuginosus). In 1952-53 the disease was found in Ladino white clover (Trifolium repens) in the Elk Grove area of California. In 1953-54 aster-yellows-infected plants were found on the Agronomy Farm at Davis, California in plots of Ladino white clover, alsike clover (Trifolium hybridum), and red clover (Trifolium pratense). Recovery of the aster-yellows virus by aster leafhoppers confirmed the identity of the disease. In 1957-58 the disease recurred, in severe form, in the Ladino clover nursery at Davis. Selection stocks were damaged extensively and a large number of clones were entirely eliminated. This study was made 1) to investigate the effect of the virus on the external and internal morphology of Trifolium species, and 2) to describe the symptoms of aster yellows on clovers.

LEAFHOPPER TRANSMISSION TESTS

Noninfective aster leafhoppers, Macrosteles fascifrons, were fed on naturally infected Ladino, alsike, and red clover plants showing stunting, chlorosis, rosetting, phyllody, and virescence (Figs. 1, 2, 3). The leafhoppers were fed on the infected clover plants for 5 to 7 days and then transferred to healthy test plants for a period of 3 to 6 weeks. Aster-yellows virus was readily recovered by the leafhoppers from 12 of 15 plants tested and transmitted to 19 Plantago major, 22 Nicotiana rustica, 2 Vinca rosea, 7 celery, and 2 aster plants. All test plants developed typical symptoms of the aster-yellows disease.

Ladino, alsike, and red clover plants were also readily infected experimentally with the aster-yellows virus. Infective aster leafhoppers transmitted the virus to a high percentage of the clover plants on which they fed and infected 24 of 25 Ladino, 25 of 25 alsike, and 19 of 20 red clover plants tested. In 2 to 3 weeks the plants developed symptoms consisting of dwarfing, chlorosis, and marginal purpling of leaves (Figs. 5, 6). Infected young seedling plants usually failed to develop flowers. However, when older red clover plants were exposed to leafhoppers the flowers developed virescence and phyllody as observed on naturally infected plants in the field.

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[1]Acknowledgment is due agronomists E. H. Stanford and W. E. Nyquist for their cooperation and for the use of field plots.

[2]Contribution from the University of California, Departments of Plant Pathology and Entomology at Davis and Berkeley, respectively.

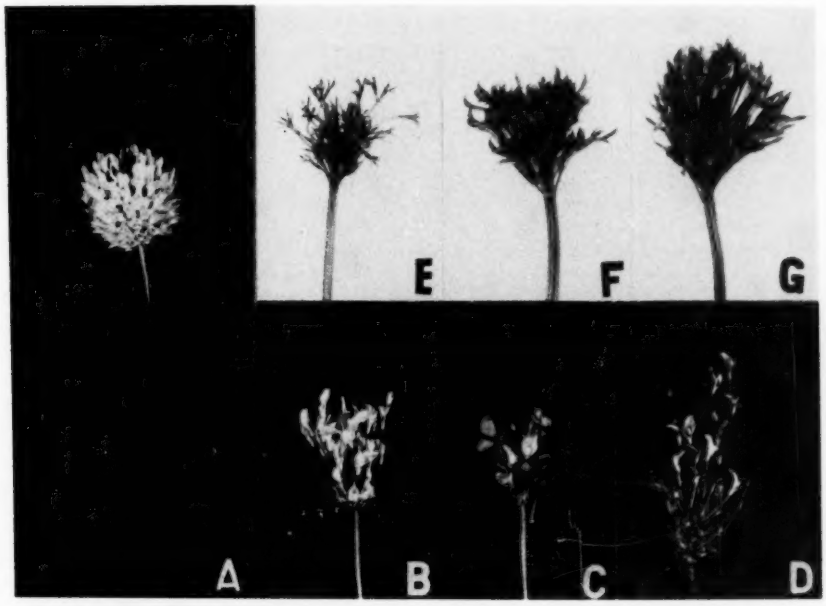

FIGURE 1. Floral virescence and proliferation in Ladino white clover infected with aster-yellows virus. A -- normal inflorescence; B, C, D -- infected inflorescences showing mixtures of normal white florets, virescent florets, and proliferated florets; and E, F, G -- infected inflorescences bearing virescent petals and sterile florets.

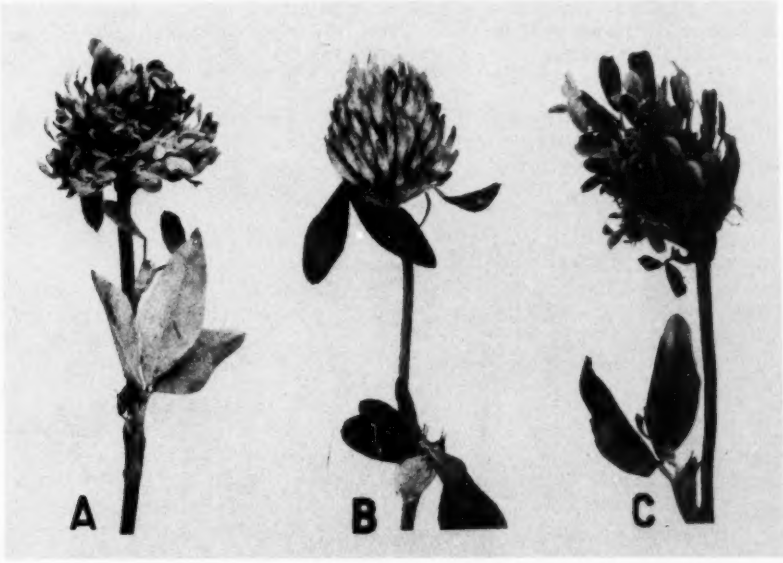

FIGURE 2. Red clover showing A, C -- inflorescences from plants naturally infected with aster yellows. Flowers show virescence and phyllody; B -- normal flower head.

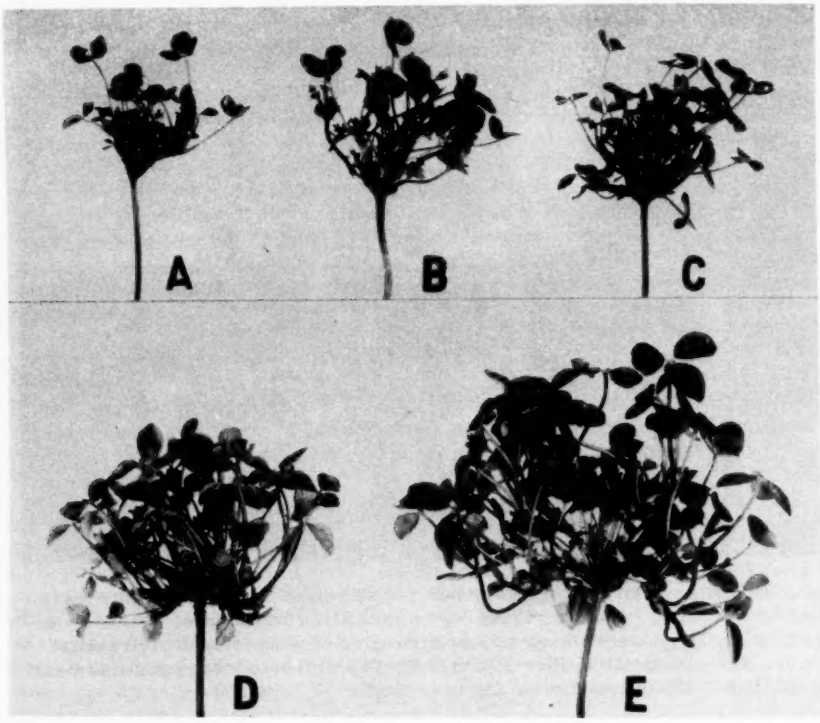

FIGURE 3. Phyllody symptoms in Ladino white clover infected with aster yellows, showing various degrees of floral proliferation. The peduncles subtend clusters of foliage leaves rather than normal seed heads.

FIGURE 4. Stolons from Ladino white clover plants infected with aster yellows. A -- terminal leaf clusters developed on infected stolons; B -- lateral leaf clusters proliferated at the nodes of infected plants.

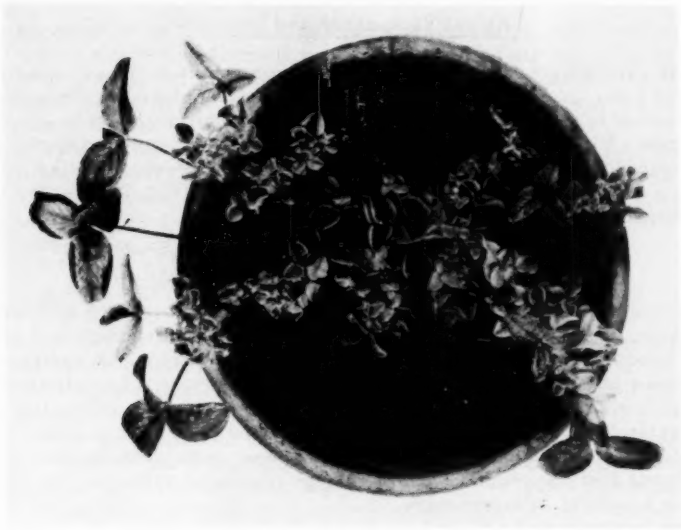

FIGURE 5. A red clover plant experimentally infected by leafhoppers with the aster-yellows virus. Growth is severely stunted and large numbers of dwarfed leaves are proliferated along the stems.

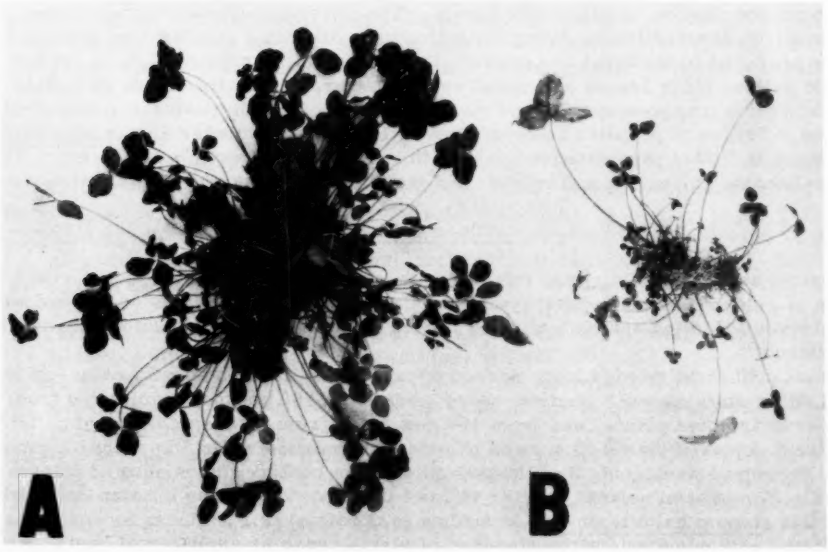

FIGURE 6. Alsike clover plants showing A -- a normal greenhouse seedling, and B -- a seedling experimentally infected with aster-yellows virus expressing chlorosis and severe stunting of leaves.

SYMPTOMATOLOGY

Floral Virescence and Sterility

Virescence is generally referred to as "the state or condition of becoming green through the development of chloroplasts in organs normally white or colored." This characteristic symptom was common in the inflorescences of white and red clover plants infected with the aster-yellows virus. Virescent heads of white clover are characterized by the development of green color in petals that are normally white (Fig. 1). Such green, pod-like florets usually fail to produce any seed. Alsike clover and red clover plants (Fig. 2) infected with aster yellows also commonly manifest floral virescence and sterility.

Phyllody and Floral Proliferation

Phyllody denotes a disease symptom characterized by the reversion of floral organs, such as sepals and bracts, to leaves. This type of retrograde metamorphosis is frequently manifested by clover infected with aster-yellows virus. A range of phyllody symptoms characteristic of aster yellows in Ladino white clover is shown in Figure 3. An individual ovary may simply proliferate into foliage leaves (Fig. 3A), or a single floret may proliferate into a secondary flower cluster (Fig. 3B). If phyllody is pronounced each pedicel in the inflorescence may elongate into a petiole, subtending a cluster of leaves rather than an individual floret. The over-all effect is that the peduncle bears a large cluster of distorted florets and foliage leaves rather than a normal inflorescence.

Aster-yellows infection in Ladino white clover may be expressed by varied degrees of floral proliferation (Fig. 1). Normal florets on abnormally elongated pedicels are shown in Figure 1B; mixtures of normal white florets, virescent florets, and proliferated florets on the same inflorescence are shown in Figures 1C and 1D.

Leaf-Cluster Proliferation

Rosette-like leaf clusters are commonly associated with aster-yellows infection in plants. White clover plants infected with aster-yellows virus often bear a dense cluster of foliage at the terminal portion of each stolon (Fig. 4A) and laterally at each node of the stolon (Fig. 4B).

Symptoms are similar in red clover plants. The severely stunted plant in Figure 5 bears a large number of dwarfed leaves along the stems, resulting in a rosette-like appearance.

Leaves produced in terminal and lateral clusters on clover stems (Figs. 4, 5) are chlorotic to pale yellow; older leaves are usually reddish-purple. Entire clones of Ladino white clover in field plots may assume a bright reddish-purple color, in contrast to noninfected green clones. Traces of purplish color in plots of Ladino white clover are usually evidence of incipient infection. This pigmentation spreads throughout the clone in a few weeks. The leaves later become shrivelled and brittle, and the entire clone is vegetatively suppressed.

Phloem Necrosis

Anatomical aberrations in plants infected with viruses commonly include necrosis and hyperplasia of phloem tissues. Aster-yellows-infected and healthy plants of red and white clovers were sectioned for anatomical study. Both species showed characteristic degeneration of phloem tissue.

Abnormal proliferation of phloem tissues apparently is associated with aster-yellows infection in Ladino white clover. Sections were made from 100 peduncles collected from a large number of infected plants, and from 100 peduncles from disease-free plants. Of the peduncles from diseased plants 93 showed phloem proliferation while 7 appeared normal anatomically. By comparison, only 3 of the peduncles from healthy clones showed phloem proliferation while 97 appeared normal. Aster yellows is known to produce similar degenerative changes in flax (Linum usitatissimum) according to Girolami (2). Phloem necrosis has also been associated with numerous virus diseases of plants, such as curly top of beets, leaf roll and blue stem of potatoes, leaf curl of raspberries, big bud of tomatoes, bunchy top of bananas, white stripe of corn, and the phloem necrosis diseases of tea, olive, and elm trees.

Stunting and Rosetting

Aster-yellows infection in plants is usually characterized by a general hypoplastic effect, shown in a pronounced shortening of the internodes of infected stolons (Fig. 4B) and in dwarfed and distorted leaves (Fig. 5). Experimentally infected clover plants usually show stunting, chlorosis, and rosetting, often resulting in premature death. The dwarfing effect of the aster-yellows virus on alsike clover is shown in Figure 6.

Diseased Ladino white clover is often stunted by a shortening of the peduncles. Peduncles bearing inflorescences showing virescence or phyllody were dwarfed substantially. When 100 peduncles from diseased plants and 100 from healthy plants were compared, the range of peduncle length was 7.87-25.4 cm, averaging 15.49 cm in healthy plants, and 2.38-16.26 cm, averaging 7.62 cm in diseased plants.

DISCUSSION

The presence of certain species of Leguminosae among naturally infected weed hosts of the California aster-yellows virus was reported by Frazier and Severin (1) in 1945. Several short reports in the literature later indicated that clovers might be hosts of the aster-yellows virus. In 1950 McWhorter (3) suspected aster yellows on alsike clover in Oregon though he made no tests to prove the presumed etiology. His description of the symptoms indicates correct diagnosis. Raymer and Amen (5) related a phyllody condition in Ladino clover to the late-breaking virus disease of potatoes in Oregon. Raymer (4) later identified the virus and host range more specifically as a strain of aster yellows, transmitted both by grafting and by the aster leafhopper (Macrosteles fascifrons) with Ladino, red, alsike, and crimson clovers included in the host range. From the eastern potato-growing areas in Maine a phyllody condition in Ladino clover was also reported by Webb and Schultz (7). They suspected the diseased clover of being a possible source of the virus causing purple-top wilt in potatoes.

The need for characterization of the aster-yellows disease on clovers is reflected in the literature. A disease of clover similar to that described here was recently discussed by Sampson and Western (6) as a "Disease of Unknown Origin." The authors reported a condition in white clover, known for many years, in which the carpels were replaced by green leaves. They also found a large plot of red clover, destined for seed production, that showed a similar type of proliferation, and a clustering of pale green leaves in the flower head. No seed was produced and the plants finally developed a dense, bunchy growth. The authors did not know whether the diseases on red and white clover were related in any way. A descriptive report of the aster-yellows disease on clovers may thus help other workers recognize the disorder.

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ATTEMPTS TO DEMONSTRATE THE TRANSMISSION OF PLANT VIRUSES BY PLANT PARASITIC NEMATODES

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Although to date a virus itself has not been recovered from a nematode, nematodes are thought to transmit viruses, and workers in animal and human parasitology have reported the role of nematodes in virus transmission. Shope (12, 13, 14, 15) demonstrated that nematode larvae may serve as intermediate hosts and vectors for swine viruses. In 1947 Syverton, McCoy, and Koomen (17) reported that the virus of lymphocytic choriomeningitis was carried internally by larvae of Trichinella spiralis (Owen, 1835) Rail., 1895, serving as intermediate hosts, and that these larvae could transmit the disease to susceptible hosts. In the same year Tykać (18) observed that Ascaris suum Goeze, 1782, might transmit a virus causing infectious paralysis of pigs. More recently it has also been reported that the larvae of Setaria digitata (Linst., 1906) Rail. & Henry, 1911, may transmit the virus of Japanese B encephalitis (4), while the migration of Toxocara canis (Werner, 1782) Johnston, 1916, larvae was shown to be effective in initiating conditions which facilitated localization of a virus in the nervous system of mice (10). Other experiments (11, 19) indicate that larvae of Nippostrongylus muris (Yokogawa, 1920) Lane, 1923, and Ascaris suum may be involved respectively in viroses of rabbits and pigs.

Some workers in plant pathology have suggested the possibility of nematodes' acting as vectors for soil-borne plant viruses (5, 7, 8). Allen (1) in 1948 and McKinney (9) in 1957 attempted to ascertain the relation of nematodes to the transmission of plant viruses, but only recently, with the work of Hewitt, Raski, and Goheen (3), has such a role actually been demonstrated for plant parasitic nematodes.

In studies herein reported attempts were made to transmit a plant virus by means of plant parasitic nematodes. In the first experiment[2] both tomato (var. Rutgers) and tobacco (var. 402) seedlings were planted into each of five flats of steam-sterilized soil and grown undisturbed for approximately 2 weeks so that any roots wounded in transplanting were healed. Four of the flats were then treated with drenches of either 1) tobacco mosaic virus suspension; 2) cucumber mosaic virus suspension; 3) and 4) suspensions of these viruses plus approximately 173,000 root-knot nematode larvae (Meloidogyne spp.) per flat. The fifth flat was an untreated control. After 2 months the plants were examined. The roots of the plants in the flats to which nematodes had been added were all heavily galled. All but 1 of 44 control plants were free of virus symptoms. Nineteen of the 74 plants drenched with virus suspensions alone and 19 of the 65 plants drenched with virus suspensions plus root-knot nematode larvae were positive for virus symptoms.

It has been shown (2) that direct inoculation of the roots of both tobacco and tomato plants with several viruses resulted in good root infection but in no infection of the aerial parts of the plants. Therefore, two tomato and two tobacco plants, negative for foliar symptoms of a virus, were taken from the above mentioned flat drenched with a tobacco mosaic virus-nematode suspension, and were checked for the presence of the virus. The roots of all four plants were negative for tobacco mosaic virus.

Under the conditions of this experiment root-knot nematodes did not increase the incidence of either tobacco or cucumber mosaic in tobacco or tomato plants.

A second experiment was initiated with the carnation mottle virus, for which no vector is known (6). Previous work (16) had shown that the spiral nematode, Helicotylenchus nannus Steiner, 1945, an ectoparasitic and migratory form, wounded carnation roots. Current studies indicate that pin nematodes, Paratylenchus spp. Micoletzky, 1922, are often associated with greenhouse-grown carnations. A mixed population of these two plant parasitic nematodes was used to inoculate mottle-infected carnation plants, which were then grown in the greenhouse for 7 months. Before discarding, these virus-infected source plants were checked for presence of the virus by juice inoculations to Chenopodium amaranticolor Coste & Reyn., and carnation mottle virus was recovered from both the tops and the roots.

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Perpetual Giant Mixed carnation plants, Dianthus caryophyllus L., were grown from seed[3] and one plant was used in each of 4 replications of the following 4 treatments: 1) Control plants; 2) plants inoculated with nematode-infested soil; 3) plants inoculated with washed nematodes; 4) plants inoculated with rinse water. For treatments 2 and 3 all the soil, plus nematodes from the pots in which the mottle-infected carnation source plants had been growing, was divided into 2 equal parts. One part was immediately added to the pots in treatment 2. The remainder was washed through 40-mesh, 200-mesh, and 325-mesh sieves. The screenings collected from the 200-mesh sieve were placed in a Baermann funnel overnight and the nematodes obtained were used to inoculate the plants in treatment 3. Approximately 1/10 of the screened water was collected and used to drench the soil of the pots in treatment 4. Through dilution counts it was ascertained that approximately 3000 spiral and 500 pin nematodes were added to each pot in treatments 3 and 4.

Two months after they were inoculated the tops of the carnation seedlings were indexed for the presence of carnation mottle virus by juice inoculations to Chenopodium amaranticolor. One month later the roots of the same carnation plants were also indexed for the presence of the virus. In no case was carnation mottle virus recovered from any of the plants in any of the four treatments.

Under the conditions of this experiment neither Helicotylenchus nannus nor Paratylenchus spp. increased the incidence of carnation mottle virus.

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[3]Seed obtained from the American Bulb Co.

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AN EVALUATION OF METHODS FOR DETERMINING THE NUMBER OF NEMATODES IN SOIL[1]

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Summary

Three methods for determining the number of nematodes in soil were compared: the Baermann funnel, the sieving-Baermann funnel, and the inverted flask techniques. Characteristics of each method were determined and described. Variability was too great and yields were too poor for quantitative studies with the first two methods. The inverted flask method provided good yields and lower variability and results were quite adequate for many quantitative purposes.

Several methods have been used to obtain nematodes from soil. The advantages and disadvantages of some of these, particularly the sieving-Baermann funnel technique, have been discussed previously (2, 5, 6). In this study three methods requiring relatively simple equipment were examined to determine their usefulness for quantitative studies. These methods were: 1) the Baermann funnel technique of Anderson and Yanagihara (1); 2) the sieving-Baermann funnel technique of Christie and Perry (3); and 3) the inverted flask technique of Seinhorst (4, 7).

METHODS

The following descriptions are detailed in order to present modifications that have been found to be useful in increasing the efficiency of the methods.

The Baermann Funnel Technique

A disc of 16-mesh aluminum screen wire, approximately 90 mm in diameter, was placed in a 125 mm glass funnel and covered with water to a depth of 10 to 15 mm. A single-thickness piece of wet-strength facial tissue (Scotties, manufactured by the Scott Paper Co.) on which soil had been spread was placed in the funnel where it settled onto the screen. After 14 to 24 hours all the liquid in the funnel was drawn off into a 10-ounce glass tumber having vertical sides.

Material in the tumbler was allowed to settle for at least 0.5 hour per inch of suspension. After settling, one half the volume was decanted and the process was repeated. The remaining suspension was poured into a 90 mm Petri dish and the nematodes were counted.

This decanting procedure is part of the procedure of all three methods studied. Therefore, error resulting from its use affects the results of all. Frequent checking has revealed that if the procedure described above is carefully followed losses of nematodes are 0.5 percent or less. Tumblers having sloping sides should not be used because their use results in excessive losses. A small siphon may be used to remove excess liquid but, because of currents set in motion if the intake orifice is placed too close to the bottom of the tumbler, its use is tedious and risky.

The Sieving-Baermann Funnel Technique

Soil was placed in a 12-quart pail and dispersed by hand or electric stirrer in 2 to 3 quarts of water. The suspension was poured through a U.S. No. 60 sieve into a second pail. Material that would pass through the sieve was washed into the pail and material that remained on the sieve was discarded. The suspension in the pail was thoroughly roiled, allowed to settle for 15 to 30 seconds, and then poured through a U.S. No. 270 sieve into the first pail.

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[1] The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published with the approval of the Director.

The screen was held at an angle and the suspension was poured onto the high side and allowed to run down across the sieve. Material that would pass through the screen was gently washed into the pail and the nematodes and debris remaining on the screen were washed with approximately 50 ml of water into a beaker. The suspension in the pail was again roiled, allowed to settle, and poured through the screen as before. Also as before, after gentle washing nematodes and debris were washed into the beaker. This process was repeated three times more with the result that the nematodes were collected in approximately 250 ml of suspension.

The volume of this suspension was reduced to approximately 50 ml by the decanting procedure outlined above and then was poured into a Baermann funnel prepared as described above. The remainder of the procedure was the same as that for the Baermann funnel technique.

The suspension of nematodes obtained from the sieves should be allowed to settle for a few minutes, then poured through a double thickness of tissue on a screen disc in a Baermann funnel. The suspension should not be roiled until the supernatant poured into the funnel covers the tissue. Whereas this modification takes less time than the method used, it is more difficult to obtain a reasonably clean suspension from the funnel. The numbers of nematodes collected are essentially the same either way.

More rapid and complete dispersion of the soil in water was accomplished by mechanical stirring than by hand mixing. The mixture was stirred for approximately 3 minutes.

The Inverted Flask Method

Sets of flasks of two sizes were used (Fig. 1). One set was a 500 ml volumetric flask inverted over a 300 ml Erlenmeyer flask and the other was a 1000 ml volumetric flask inverted

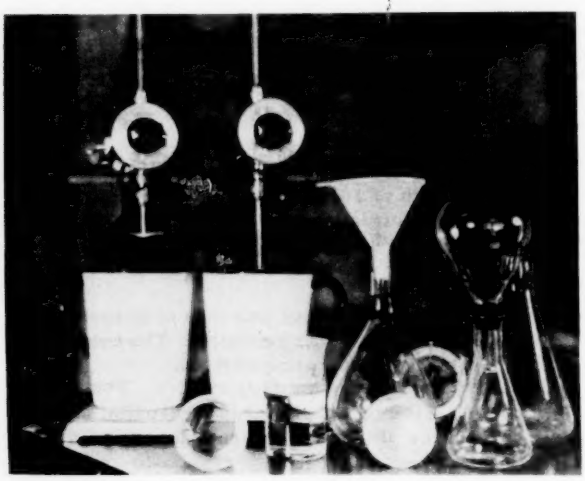

FIGURE 1. Equipment for the inverted flask method. Back row, left to right -- hollow spindle stirrers and 200 ml beakers, 1000 ml volumetric flask with funnel and kitchen strainer. Front row, left to right -- filter cup showing screen bottom, filter cup in tumbler, filter cup with tissue and cylinder in place, and 500 ml volumetric flask inverted and inserted into 300 ml Erlenmeyer flask.

over a 1000 ml Erlenmeyer flask. In both the necks of the volumetric flasks were cut to a length of approximately 75 mm. This is about the maximum length that can conveniently be inserted into the Erlenmeyer flasks. Rubber stoppers fitted into the necks of the Erlenmeyer flasks were pushed down as far as they would go around the necks of the volumetric flasks and served to seal the union between the flasks. Soil suspensions were prepared in the manner described by Seinhorst (7) and by mechanical stirring.

In the latter procedure soil was stirred for 3 minutes in enough water to make a total volume of 1500 ml. Immediately after stirring the suspension was poured through a kitchen strainer supported in a funnel into a volumetric flask until the flask was filled. The flask was allowed to stand for a minute or so and then froth and floating debris were removed. The suspension was agitated by inverting the flask twice and then the neck of the flask was inserted into an Erlenmeyer flask that had previously been filled with water. The flasks were set aside

and material from the upper flask was allowed to settle into the lower flask for a specified period of time. After this the flasks were separated and the contents of the volumetric flask were poured through a stack of sieves consisting of two U.S. No. 325 sieves surmounted by two U.S. No. 270 sieves. The sieves were washed gently until the effluent was clear, then the material caught on each sieve was washed with a small amount of water into a tumbler or beaker. The material in the Erlenmeyer flask was returned to the volumetric flask and the process was repeated.

If the processing time had been long enough (more than 3 minutes) to provide a very clear suspension, the material on the sieves was washed into a tumbler and the volume was reduced by the decanting procedure described above. After shorter processing times, material on the sieves was collected in a beaker and poured through a double thickness of tissue supported in a filter cup set in a glass tumbler.

The filter cup was made from a tapered plastic tumbler that had a greater diameter larger than that of the glass tumbler and a lesser diameter smaller than that of the glass tumbler. It was cut to form a tapered tube that would be supported by the tumbler and extend approximately 1 inch into the tumbler. An aluminum screen-wire disc was fused to the smaller end of the tube with a plastic-sealing iron.

A double thickness of tissue was laid over the top of the filter cup and pushed down onto the screen with a plastic cylinder that fit fairly snugly inside the cup. After settling for 5 to 10 minutes, the suspension of nematodes was poured through the tissue in a cup in a tumbler while the cylinder was still in the cup. The level of liquid in the tumbler was raised so that it submerged the tissue by about 5 mm before the final bit of suspension in the beaker was roiled and added. The cylinder was then removed. A piece of wire hooked over the lip of the tumbler provided a vent between the tumbler and filter cup which prevented entrapment of air bubbles under the screen.

After 14 to 24 hours the filter cup was removed and the volume of suspension in the tumbler was reduced as described above.

For quantitative work, it is essential to catch all of the suspension that passes through the tissue. Some nematodes pass through the tissue while the suspension is being poured into the cup. The number that pass through is determined, to a large extent, by the mechanics of the process rather than by the number of nematodes in the suspension. In a large number of tests with suspensions having numbers of nematodes ranging from 100 to 5000 the numbers that passed through the tissue while suspensions were being poured into the cups ranged from 30 to 600. Although there was a tendency toward a direct relationship between these two sets of data, they were not proportional. Consequently, the percentage of nematodes that passed through the tissue was usually much greater for suspensions containing small numbers than for those containing large numbers of nematodes.

In all procedures numbers of nematodes were determined by counting the nematodes in 5 or 10 percent of the area of 90 mm Petri dishes under a stereoscopic microscope. The suspensions in the dishes were agitated by moving the tips of curved forceps to and fro across the dish in order to avoid swirling and its resulting uneven distribution of nematodes as much as possible. The nematodes were allowed to settle and the appropriate number of fields were selected at random over the area of the dish.

This procedure is quite accurate unless the number of nematodes is very low (2 or less per field) or very high (more than about 40 per field). The most convenient and accurate counts were made when there were from 5 to 25 nematodes per field.

RESULTS

Characteristics of the Baermann Funnel Technique

This method is the simplest and fastest of the methods considered here and the nematodes are collected in a clear, essentially debris-free, suspension. However, with equipment of reasonable size its use is limited to very small amounts of soil. Yields per unit of soil decreased markedly when more than 20 gm of soil were used. As would be expected, the use of small samples resulted in a high degree of variability. In 13 tests using 10 gm samples the coefficient of variability was 10 percent or lower in one test and 25 percent or lower in three tests. In 14 tests using 20 gm samples the coefficient of variability was 10 percent or lower in two tests and 25 percent or lower in eight tests. Doubling the size of sample reduced variability. However, further increase in size of sample was impractical because of the marked reduction in yield. Furthermore, variability tended to increase with samples heavier than 20 gm.

Probably adverse conditions, such as anaerobiosis and mechanical hindrance, in the larger quantities of mud in the funnels prevented the movement of nematodes out of the soil.

Characteristics of the Sieving-Baermann Funnel Technique

This method is cumbersome and time consuming. Large volumes of water (8 to 10 quarts) must be handled. Large quantities of soil can be processed, but there is a limit to the size of sample. Results of a limited number of tests indicated a marked reduction in yield per unit of soil when more than 400 gm of soil was processed. These results were obtained when the soil was dispersed by hand. Somewhat greater quantities of soil could be processed if the soil was dispersed by mechanical stirring. Also, yield seemed to be improved by stirring.

Large quantities of soil and debris were collected, especially in the first sieving, with the U. S. No. 270 sieve which caught up to 80 percent of the nematodes obtained. This material was retained on the tissue in the Baermann funnel with difficulty and frequently was in amounts great enough to affect yield and variability adversely. This effect was great enough to more than offset the advantage of large size of sample. In 13 tests the coefficient of variability was 10 percent or lower in two tests and 25 percent or lower in nine tests.

Characteristics of the Inverted Flask Method

This method is convenient and somewhat less time consuming than the sieving-Baermann funnel technique. Relatively large quantities of soil can be processed. Nematodes are obtained in relatively debris-free suspensions and are actively motile rather than immobile, as in the Baermann funnel method. If the filter cup is eliminated from the procedure, inactive as well as active nematodes can be collected. Use of the filter cup makes the collection of nematodes dependent upon their activity, as in the other methods.

The yield and variability of this method were found to be affected by the quantity of soil processed, the method of dispersing the soil in water, the duration and number of processing times, the size of flasks used, and the size of nematodes in the soil.

Yield per unit of soil increased and variability decreased as the total volume/soil weight ratio was decreased to about 4 when soil was dispersed by hand. Below this ratio yield decreased and variability increased. Thus, the maximum amount of soil that could be processed was 125 to 250 gm, depending upon the capacity of the flasks. When stirred mechanically, a total volume/soil weight ratio of about 4 was also optimal. However, because an aliquot of the stirred suspension was processed in the flasks, larger volumes and, therefore, larger quantities of soil could be used. Thus, with a volume of 1500 ml about 375 gm of soil could be processed.

Because an aliquot was used in this procedure it was necessary to determine whether the nematodes were uniformly distributed throughout the suspension. Several suspensions were checked by determining the number of nematodes in successive 100 ml aliquots. The number of nematodes in individual aliquots varied between 85 and 115 percent of the mean number for all aliquots. There was a slight tendency for the first 3 or 4 aliquots to be below the mean, the next 6 to 8 to be above the mean, and the last 3 or 4 to be below the mean. When 200 or 500 ml aliquots were examined, the number of nematodes in the individual aliquots varied between 93 and 108 percent of the mean for all aliquots and there was no apparent pattern of variation. Therefore, it was concluded that if large aliquots were taken from the suspension they would contain representative numbers of nematodes.

The most suitable time of processing in the flasks is the shortest time that will provide a suspension that is reasonably free from debris. This was found to be about 3 minutes for the first processing and 2 minutes for the second processing of the silt-loam and sandy soils that are most frequently encountered in this laboratory. Soils with a high clay content required somewhat longer times. Processing times of 4 or 5 minutes provided very clear suspensions that did not require the use of the filter cup. However, the yield of nematodes was much lower than that from processings of 3 minutes or less. Occasionally second processings of 1 minute duration were satisfactory, but usually the suspensions were too muddy to be useful.

When 1000 ml flasks were used and samples were processed twice, 3 and 2 minutes, 50 to 70 percent of the nematodes obtained were collected from the first processing. When samples were processed three times, 3, 2, and 2 minutes, 93 to 96 percent of the nematodes obtained were collected from the first two processings. When samples were processed four times, 3, 2, 2, and 2 minutes, 90 to 94 percent of the nematodes obtained were collected from the first two processings and 95 to 98 percent from the first three processings. When samples

were processed five times, 3, 2, 2, 2, and 1 minute, the percentages of the total nematodes obtained were 86 to 91, 92 to 95, and 95 to 97 for collections from the first two, three, and four processings, respectively. Assuming that the five processings accomplish a nearly complete extraction of nematodes from the soil, it was concluded that two processings were necessary and would usually be sufficient for quantitative determinations of the number of nematodes in soil.

When 1000 ml flasks were used, the number of nematodes collected per unit of soil was approximately 20 percent greater than when 500 ml flasks were used. Variability was about the same with both sizes of flasks. In 12 tests using 1000 ml flasks, the coefficient of variability was 10 percent or lower in 6 tests and 25 percent or lower in all 10 tests. In 19 tests with 500 ml flasks, the coefficient of variability was 10 percent or lower in 10 tests and 25 percent or lower in 8 tests. The variability of this method was much lower than that of the other two methods.

Large nematodes, such as species of Xiphinema, Dorylaimus, and Hoplolaimus, tend to settle more rapidly than smaller nematodes. Consequently, the percentage of large nematodes is greater in collections from second processings than in collections from first processings.

The reliability of the inverted flask method, as outlined above, was checked in the following manner: A large quantity of soil was thoroughly mixed and 300 gm-aliquots were put through the procedure using 1500 ml soil-water suspensions stirred 3 minutes; two processings (3 and 2 minutes) in 1000 ml flasks; and filter cups.

Each aliquot of soil was put through the procedure three times. After the 1000 ml aliquot from the first suspension was poured into a volumetric flask and processed, water was added to the remaining 500 ml until the volume was again 1500 ml and the procedure was repeated. The 500 ml of suspension remaining from the second treatment was again made up to 1500 ml and the procedure was repeated a third time.

The theoretical yields of the three processings, expressed as percentages, are as follows:

First	1 x 2/3	66.7 percent
Second	1/3 x 2/3	22.2
Third	1/9 x 2/3	7.4
Total		96.3

The percentage yield of each processing was calculated, using a corrected total (total number of nematodes from the three processings/.963, the theoretical percentage of the total number of nematodes in the sample that can be obtained by three processings). In 11 tests the mean percentages obtained for the first, second and third processings were 64.7, range 56.7-72.4; 23.0, range 16.2-33.3; and 8.6, range 6.1-11.2; respectively. These values are in good agreement with the theoretical values.

Table 1. Relative yield of nematodes per unit of soil and coefficient of variability of the inverted flask, sieving-Baermann funnel, and Baermann funnel techniques.

Test number	Inverted flask		Sieving-Baermann funnel		Baermann funnel	
	Yield	C.V.	Yield	C.V.	Yield	C.V.
1	100	4.4	35	43.6	76	9.5
2	100	15.5	33	28.1	67	28.8
3	81	10.2	--	--	100	17.9
4	100	32.5	--	--	92	28.8
5	86	12.5	--	--	100	23.1
6	100	4.4	32	19.5	--	--
7	100	4.9	60	28.4	--	--
8	100	11.7	46	11.0	--	--
9	100	15.3	77	19.0	--	--
10	100	18.0	65	38.3	--	--

Comparison of the Methods: The data in Table 1 show the relative merits of the three methods. These data plus those presented in the previous paragraphs clearly show that the inverted flask method provides the greatest yield and the least variability of the three methods studied.

DISCUSSION

The elutriation methods of Seinhorst (6) and Tarjan et al. (8) undoubtedly are the most accurate methods for determining the number of nematodes in soil. However, they require rather complex equipment and fairly large amounts of space. Seinhorst's inverted flask method as modified here is good and is less complex. It is rapid and convenient and provides accurate, reproducible results that are quite adequate for many quantitative studies.

The various operations are readily adjustable to the requirement of different kinds of soil. Soils having large amounts of clay are the most troublesome with all three methods, but such soils can be processed more easily by the inverted flask method than by the other two methods.

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POTATO-ROT NEMATODE, DITYLENCHUS DESTRUCTOR THORNE 1945, FOUND IN DAHLIA ROOTS

Harold J. Jensen, Harriet R. Smithson, and L. B. Loring[1]

Abstract

Ditylenchus destructor[2], the potato-rot nematode, was found on dahlia roots (tubers) in Oregon. Diagnosis of the infection is greatly handicapped by lack of above-ground symptoms and of characteristic root symptoms. All tuberous roots having a cortex with unusual transverse and longitudinal cracking, sloughing, or flaking of the surface, or with rotted areas, should be examined for infection. Satisfactory control measures are not known but hot-water treatment studies are in progress.

INTRODUCTION

Ditylenchus destructor was recovered from dahlia roots (tubers) in February 1958. The infection was discovered in culled material from the Portland area. Apparently several varieties of dahlias at this source were infected since the nematodes were recovered on several different dates from portions of discarded roots. A concerted effort was made to examine all commercial dahlia plantings in Oregon for the presence of this pest. This survey resulted in the discovery of the pest in two additional plantings.

SYMPTOMS

Thus far we are unable to associate the nematode with characteristic symptoms that could be used for diagnosis of infection. This has been a severe handicap for those conducting surveys. No above-ground symptoms or unusual growth behavior were associated with the infected roots. The cortex of most dahlia roots is usually roughened in some manner, which greatly hinders an early detection of superficial necrosis that may be the result of an initial infection. Any area with unusual transverse or longitudinal cracking (Fig. 1), or showing evidence of cortex flaking or sloughing, should be regarded with suspicion. Evidence of this kind is not to be considered diagnostic because such loci are not necessarily sites of infection. Wherever an infection has been found, however, it was associated with these conditions.

The few roots that we have seen in a more advanced stage of infection appear to show symptoms as described for the same pest in potatoes (Fig. 2). In this case the infected tissues are discolored brown to black. The progressive breakdown is of a dry granular type. Apparently the infection will progress slowly in storage until the root is nearly destroyed.

Dr. W. H. Hart (Nematologist in the Bureau of Plant Pathology, California Department of Agriculture, Sacramento) informed us that he recovered some D. destructor from a stem "eye." The source of this infected material was also from the Portland area of Oregon. Dr. Hart also mentioned that the diseased "eye" and adjacent stem tissue showed evidence of a dry-rot condition.

VARIETIES INFECTED

We have not made a specific effort to determine the dahlia host range for this pest, but infections have been observed in the following named varieties: Brandaris, Pop Harris, Oakleigh Champion, Gold Rose, K. S. Snowball, Mary Elizabeth, Kidd Climax.

ACTION TAKEN

Once the identity of the pest had been determined, the sale of dahlia roots from the site of

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[2] Confirmed by Professor Gerald Thorne, Department of Plant Pathology, University of Wisconsin; and by A. L. Taylor, Principal Nematologist in Charge, Nematology Section United States Department of Agriculture, Beltsville, Maryland.

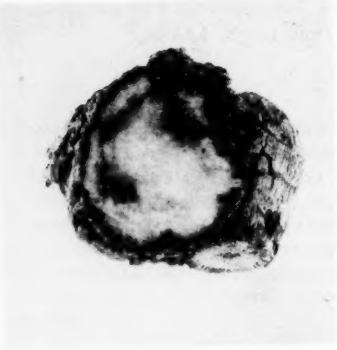

FIGURE 1. Cross-section of an infected dahlia root (tuber). Note (a) the longitudinal and transverse cracking of the root cortex; and (b) the necrotic interior showing numerous patches of infected tissue.

FIGURE 2. Longitudinal-sections of a diseased dahlia root (tuber) showing an advanced stage of infection. Note also the sloughing of the cortex from the smaller roots.

the initial discovery was restricted. Mr. Frank McKennon (Chief, Bureau of Plant Industry, Oregon State Department of Agriculture) then relayed this information to the other members of the four Regional Plant Boards, to the Plant Pest Control Division, United States Department of Agriculture, and to the Agricultural Departments of those States receiving dahlia shipments from the site of the initial infection. Additional surveys during the 1958-59 winter storage period and investigation of various control measures are contemplated.

DISCUSSION

Origin of the infection is usually a controversial subject, especially when constructed, at least partly, on circumstantial evidence. The original source of planting stock for many dahlia growers is from foreign areas. The principal source of special planting material is usually Western Europe, although a few other areas may also be involved. The limited amount of inspection of imported European stock that we were able to do failed to reveal Ditylenchus destructor on any of the tuberous roots. Nematodes such as Pratylenchus penetrans were surprisingly numerous. In June 1958, we found Ditylenchus destructor in dahlia roots that had been imported from South Africa.

In the course of the survey, several other kinds of nematodes were also found in the tuberous roots of dahlias, including Rhabditis, Diplogaster, and Aphelenchus species. These are saprozoic forms found in all kinds of decaying plant tissue and are not known to have any significance as parasites. Because the identity of Ditylenchus destructor is so difficult to determine, we suggest that specimens from dahlia roots be sent for confirmation to investigators familiar with this genus.

The potato-rot nematode has been considered a serious pest of potatoes for a number of years (1, 3, 5). The threat of this nematode to the potato industry has resulted in the adoption of regulatory measures to govern the movement of infected tubers. Bulbous iris (2, 4) is also known to be a host of Ditylenchus destructor. The identity of the nematode in iris remained in a controversial status until recent laboratory and field transfers between potato and iris indicated that only a single species is involved.

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CHEMICAL CONTROL OF DITYLENCHUS DIPSACI (KÜHN) FILIPJEV IN ORGANIC SOILS OF SOUTHERN NEW YORK[1]

G. D. Lewis[2] and W. F. Mai[3]

Summary

Organic soils used for onion culture in southern New York and infested with Ditylenchus dipsaci (Kühn) Filipjev were fumigated with D-D (a mixture of 1,2-dichloropropane and 1,3-dichloropropene) at rates of 50 or more gallons per acre. All treatments resulted in excellent control. No infected onions have been found in the fields for 2 years.

No injury resulted in the onion crops following fumigation even with a total rate of 110 gallons per acre.

Onion bloat, caused by Ditylenchus dipsaci (Kühn) Filipjev, has been an important problem since 1954 on the organic soils of southern New York (4). Rotations of 2 or 3 years with nonsusceptible crops have been shown to give excellent control or, sometimes, apparent eradication. It is unfortunate that the rotation method of control is not acceptable to many of the onion growers of this region. These growers have adopted a one-crop system for economic reasons. Many who attempted to use the rotations lost more money than they had lost from the nematode. These growers found themselves in a position where they could not afford to grow onions because of the rapid increase of infestations in their land, but they could not afford to grow any other crop. It was clear by 1955 that these growers needed a practical chemical control method if they were to continue to grow onions profitably. Various heat and chemical control measures had been attempted by earlier workers, but the methods tried either were too expensive or they did not result in a sufficient degree of control.

The experiments described gave rise to a chemical control which is acceptable to the growers concerned with the problem.

LITERATURE REVIEW

Steam was the first successful treatment for the control of D. dipsaci in organic soils (8). This treatment appeared to eradicate the nematode in the treated area, but the cost was too great and the obtaining of steam-generating equipment was too difficult to allow growers to adopt the method.

Several obstacles are met in attempting to fumigate organic soils for control of D. dipsaci. These soils usually require an increase of 50 to 100 percent in the amount of chemical needed to give satisfactory nematode control in most mineral soils (10). Many of the proven nematocides contain bromine, and residues that are toxic to onions are often left in the soil after the use of bromine-containing fumigants (1, 5, 7).

Chloropicrin (trichloronitromethane) has been used against D. dipsaci in home gardens with satisfactory results (2). This material has also been used successfully in organic soils, but the cost of the chemical plus the cost of applying a gas-proof seal results in a treatment that is uneconomical for the grower (9).

D-D (1,3-dichloropropene and 1,2-dichloropropane), like chloropicrin, has been used in home gardens in instances where personal reasons permit a high cost of treatment (11). D-D was used at rates from 30 to 50 gallons per acre in organic soils of northern New York. The lower rates did not give good control, and the higher rates resulted in injury to the onions under the conditions of these tests (1).

D-D gave good control of D. dipsaci attacking garlic in California. Two successive appli-

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cations of 25 gallons per acre were made (3). The soil was plowed before the second application in order to turn under the nematodes in the first few inches of soil that were not killed by the first fumigation.

MATERIALS AND METHODS

Although D-D did not give satisfactory results in a previous test in northern New York (1), this fumigant appeared to be the only commercially available and economically acceptable material that could be tried since the other fumigants suitable for large-scale use contained bromine and would be hazardous in onion soils. Growers in southern New York had tried D-D at 40 gallons per acre with inadequate control but no evidence of injury to the subsequent onion crops. It was decided to try D-D at higher rates and in combination with other practices in an effort to obtain acceptable control of the nematode.

Observations of infestations of D. dipsaci in organic soils indicated that the nematodes are carried to new areas of a field during cultivation of the soil. Such fields are worked continuously, even after harvest, for weed control. Extensive working of the soil is also necessary in the spring to prepare the fields for planting. The presence of infected onions in a treated area could be due either to failure of the treatment or to spread from other treatments and checks if a field were not treated uniformly. Thus, it was decided that a single treatment must be applied to an entire field.

All fumigation treatments were applied using a tractor-mounted pressure-type applicator that was equipped with shanks spaced at 11 inches. The shanks were set to deliver the fumigant at a depth of 6 inches. Each field was plowed or harrowed to a depth of 6 inches prior to fumigation, and the soil was harrowed lightly following the application to close any cracks in the soil. Soil temperatures at 6 inches were recorded on the days of application and were found to vary from 66° to 59° F.

Five fields known to be infested with D. dipsaci were located and various fumigation treatments were applied.

Field 1. A field was selected that had been severely infested in 1954, following the planting of infected onion sets. Lettuce was grown in 1955 in an effort to reduce the population of D. dipsaci to a lower level before fumigation. D-D was applied at the rate of 50 gallons per acre in September 1955.

Field 2. A field containing infected onions in 1955 was selected. Since it was known that some of the nematodes were still in bulbs left in the soil, Aero Cyanimid (47 percent calcium cyanimide) was applied at the rate of 600 pounds per acre and harrowed into the soil on August 30, 1955. Although calcium cyanimide is known to have some nematocidal action (6), it was applied with the intention of initiating decay in the bulbs left in the soil, since it is known that the partial breakdown products are toxic to plant tissue. The field was fumigated with D-D at the rate of 50 gallons per acre 3 weeks after the application of cyanimide.

Field 3. A field containing infected onions in 1955 was selected. D-D was applied in a split application in September of that year. The first application was at the rate of 60 gallons per acre. After 1 week the field was plowed, harrowed, and refumigated at the rate of 50 gallons per acre.

Fields 4 and 5. Both fields contained infected onions in 1955. D-D was applied in September at a rate of 50 gallons per acre.

The yields of each field were recorded for the summers before and after the fumigation treatments in order to get information on crop injury and nematode control. For comparison, the yields of field 6, adjacent to fields 2, 3, and 4, were recorded. Field 6 was not infested with D. dipsaci and was not fumigated. The inspection consisted of walking back and forth through each field and observing two rows of onions at each passage. All of fields 1, 2, 3, and 4 and approximately 1 acre of field 5 (that area known to be infested) were checked in this manner. All plants exhibiting symptoms similar to those of onion bloat were taken to the laboratory and checked microscopically for the presence of D. dipsaci.

The same system of inspection was carried out during the summer of 1957 in fields 1, 2, and 5. Fields 3 and 4 were incorporated into a larger field in the fall of 1956 and were discarded from the experiment.

The growers were instructed to save any bulbs at the time of harvest that appeared to be infected with D. dipsaci. These bulbs were also checked in the laboratory.

RESULTS

No plants infected with D. dipsaci were found during the field inspections of 1956 or 1957. No infected bulbs were found during the harvests of either year.

Numerous untreated fields that were known to be infested in 1955 were observed in 1956 and 1957. In all cases where these fields were planted again with onions, the infestations were more severe than they had been during the previous summers.

There was no evidence of injury to the 1956 and 1957 onion crops in any of the experimental fields. A comparison of the yields before and after fumigation is given in Table 1.

Table 1. Comparison of onion yields in experimental fields before and after fumigation.

Field number	Treatment	Yield (bushels per acre) 1954	1955	1956
1	50 gallons/acre D-D preceded by 1 year lettuce	0	lettuce	884
2	Calcium cyanimide followed by 50 gallons/acre D-D		596	1076
3	Split application of D-D 60 + 50 gallons/acre		395	1022
4	50 gallons/acre D-D		310	740
5	50 gallons/acre D-D		1032	963[a]
6	No infestation No fumigation		859	876

a Foliage blights severe in 1956.

DISCUSSION

The degree of control achieved in all fields fumigated with D-D is acceptable to the onion growers. The cost of treatment, although high (approximately $75 per acre), is also acceptable since the onions grown on the organic soils of southern New York yield well and thus are a high value per acre crop.

Telone (technical dichloropropenes), which has appeared since the experiments were conducted, should also prove to be an acceptable fumigant for the control of D. dipsaci in onion soils, as it contains the same major active ingredient as D-D.

It is difficult to believe that D. dipsaci has been eradicated from the experimental fields. It is obvious, however, that a degree of control approaching eradication was obtained because infestations of D. dipsaci enlarge rapidly in the onion soils and often double in area from one year to another. The fact that D. dipsaci is not parthenogenetic allows greater probability for eradication than would be the case with a parthenogenetic species such as Meloidogyne hapla Chitwood. The survival of D. dipsaci requires that two individuals of opposite sex meet within a host plant, while the survival of M. hapla requires that only one female enter a host plant. Thus D. dipsaci might be eradicated by a fumigation that does not actually kill every individual in the field. This thought is supported by the observations that when organic soils of the same area are treated with D-D at 50 gallons per acre for the control of M. hapla, although the degree of control is adequate from a commercial standpoint, individuals of M. hapla can be found during the first summer and infestations are apparent by the second summer following fumigation.

The lack of any apparent plant injury even in field 3, which received a total of 110 gallons per acre of D-D, conflicts with the report of injury to onions in northern New York with rates as low as 45 gallons per acre. Perhaps the difference can be explained by a difference in soil composition, a difference in onion varieties, a change in the chemical content of the fumigant since 1949, or a difference in environmental conditions following the fumigation. The characteristic odor of D-D lingered in the soil of field 3 in the spring and early summer of 1956, but

that fraction of the chemical mixture that remained was not toxic to the onions.

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CONTROL OF STING NEMATODES FOR TWO GROWING SEASONS BY SOIL FUMIGATION[1]

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Summary

Row applications of dibromochloropropane and ethylene dibromide gave good control of sting nematodes on cotton the first year after application, but only dibromochloropropane gave significant control the second year after application. Nematocides containing dichloropropene-ethylene dibromide mixture and dichloropropane-dichloropropene mixture were not as effective in this respect as the above nematocides. Yield of both cotton and corn were greatly improved by chemical treatments that effectively controlled sting nematodes.

Sting nematodes, Belonolaimus spp., have a wide distribution in the southern United States (4), where they are known to be parasites of major importance on many crop plants. Holdeman and Graham (6, 7) reported that sting nematodes and fusarium wilt cause a disease complex of cotton similar in effect to that reported for fusarium wilt and the cotton root-knot nematode, Meloidogyne incognita acrita (1, 8).

Complete crop failures are not uncommon on cotton land that has become infested with sting nematodes and fusarium wilt fungi, and chemical control appears at present the only reliable means of combating these destructive pests. Experiments (unpublished) conducted at Tifton, Georgia during 1954 and 1955 for control of sting nematodes indicated that cotton yields can be economically increased and the incidence of fusarium wilt greatly reduced by soil fumigation.

In an experiment initiated in the spring of 1956 to obtain additional information on the efficacy of several nematocides in controlling sting nematodes on cotton, spotty areas of improved vegetative growth were noted in the unfumigated control plots early in the growing season. These areas corresponded approximately to plots treated the previous year with dibromochloropropane; so the experiment was enlarged to include a second-year study on the effect of soil fumigants for controlling sting nematodes through the second growing season.

MATERIALS AND METHODS

The soil of the test field was Tifton sandy loam that was heavily infested with an undescribed species of Belonolaimus. Plains cotton, a wilt-resistant variety, and Dixie-18 corn were the crop plants grown in 1956 and 1957, respectively. The experimental design was a random block with four replications of each soil treatment. The plots were 150 feet long with four rows spaced 38 inches apart. Cultural practices consistent with those currently used in Georgia were followed throughout the experiment.

Soil fumigants were applied as row treatments with tractor-drawn equipment of the constant gravity-flow type. The chemicals were placed approximately 8 inches below the soil surface and covered by means of disc-hiller plows, which formed a ridge approximately 10 inches above the original soil surface. The following soil fumigants and rates were applied on March 20, 1956: EDB (by wt., 41 percent ethylene dibromide) at 9.5 gallons per acre, DBCP (by wt., 95 percent 1,2-dibromo-3-chloropropane) at 0.9 gallon per acre, DCP-EDB mixture (by wt., 55.2 percent 1,3-dichloropropene and 24.8 percent of 83 percent ethylene dibromide) at 8.0 gallons per acre, and DD mixture (by wt., about 50 percent 1,3-dichloropropene and 50 percent 1,2-dichloropropane) at 9.5 gallons per acre. Four weeks later the rows were opened, fertilized, and planted to cotton.

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[1] Cooperative investigation of the Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and the University of Georgia College of Agriculture, Agricultural Experiment Stations.

[2] Nematologist and Assistant Nematologist, respectively, Crops Protection Research Branch, Agricultural Research Service, United States Department of Agriculture.

Cotton yields were taken by weighing the seed cotton harvested from the inside two rows of each plot; yield data were recorded in pounds per acre of seed cotton. During the winter of 1956-1957 native weeds grew on the plots. In the spring of 1957 the land was prepared for planting by plowing and harrowing, and corn was planted, as nearly as could be determined, on the exact locations of the cotton rows of the previous year. Corn yield was taken as the weight of ears harvested from the inside two rows of each plot.

Soil samples were taken for nematode counts with a 1-inch soil sampling tube from the cotton plots on July 2, July 6, and September 4, 1956 and from the corn plots on June 11, 1957. A 150-cc sub-sample from each plot was processed by the method described by Christie and Perry (2), using a 200-mesh sieve to retain the nematodes; counts were made of the nematodes recovered after a 48-hour separation period.

RESULTS AND DISCUSSION

DBCP was the only chemical that gave significant control of sting nematodes for two crop-seasons. The data indicate that control with EDB was possibly better than for either DCP-EDB mixture or DD mixture (Table 1). During 1956 control of sting nematodes on cotton with DBCP approached 100 percent throughout the season and it persisted into the 1957 corn crop with 65 percent control at mid-season as compared with the control plots. Control of sting nematodes from applications of DCP-EDB mixture and DD mixture was not evident from the nematode data; however, had soil samples been taken earlier in the 1956 season, it is believed some control would have been detectable.

Table 1. Relative efficacy of soil fumigants applied in March 1956 for controlling sting nematodes on cotton in 1956 and on corn in 1957.

Soil treatment	Sting nematode counts on[a]			
	Cotton			Corn
	July 2	July 6	Sept. 4	June 11
DBCP	0.3[b]	0.0	0.3	53.8
EDB	8.0	6.8	49.0	127.0
DCP-EDB	8.0	22.0	89.0	128.5
DD	12.3	23.0	70.3	191.8
Control	14.3	21.3	70.0	151.2
Sig.			10 percent	10 percent
L.S.D. .05	8.1	15.1		
L.S.D. .10			61.2	72.6

a Number of nematodes recovered from a 150-cc soil sample.
b Average of four replications.

Nematode control was reflected in yields of cotton and corn; materials that gave the best control generally produced the largest yield (Table 2). DD mixture, however, was the only nematocide that did not give a significant yield increase for cotton. Average seed cotton yields from DBCP and EDB treated plots were more than 7 times the average of the unfumigated controls. Plants from plots treated with DBCP and EDB were larger and more vigorous than plants from other soil treatments, having more than twice as many mature bolls per plant as the control plants. This difference was significant. In addition, the incidence of fusarium wilt was minimal in DBCP and EDB treated plots, whereas in control plots and those given less effective chemical treatments the disease became progressively worse as the season progressed (Fig. 1). The following year, both DBCP and EDB treatments gave significant increases in corn yield, producing respectively 28.3 and 8.1 bushels per acre more corn than the unfumigated controls. Corn grown on DBCP and EDB treated plots, in addition to having more vigorous vegetative growth (Fig. 2), had larger and fuller ears than the other treatments. The mean weight of ears from DBCP treated plots was 19 percent greater than those from unfumigated control plots. This was the only significant difference.

Table 2. Effect of soil fumigation in March 1956 on yield of seed cotton in 1956 and of corn in 1957.

Soil treatment	Seed cotton (pounds per acre)	Corn (bushels per acre)
DBCP	1566[a]	63.8[b]
EDB	1605	44.6
DCP-EDB	1026	35.9
DD	884	33.4
Control	203	36.5
L.S.D. .05	727	4.8

a Average of four replications.
b Average of four replications, values are for bushels of shucked corn.

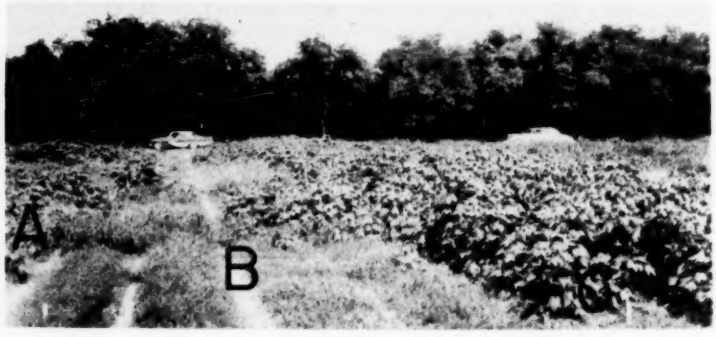

FIGURE 1. Effect of soil fumigants in controlling fusarium wilt and sting nematodes on cotton in 1956. From left to right, plots: A -- treated with DCP-EDB mixture, B -- unfumigated, and C -- treated with DBCP. Note the dense growth of crab-grass, an excellent host for sting nematodes, that developed after the last cultivation.

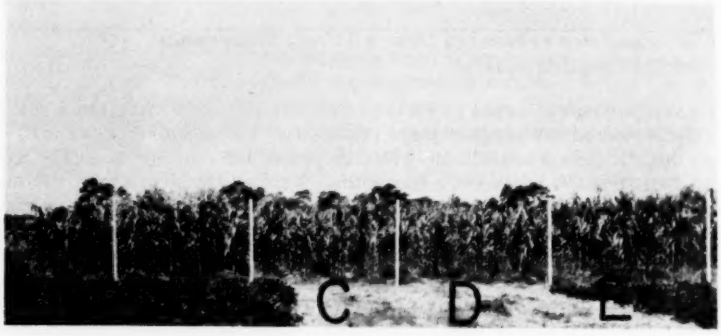

FIGURE 2. Control of sting nematodes on corn the second year after soil fumigation. From left to right, plots: A -- treated with DCP-EDB, B -- treated with DBCP, C -- unfumigated, D -- treated with DD mixture, and E -- treated with EDB.

Yield data as well as nematode counts in this experiment indicate that DBCP and EDB were more effective in controlling sting nematodes than was DD mixture. The DCP-EDB mixture, which contains both dichloropropene and ethylene dibromide, gave control intermediate between the EDB and the DD mixture treatments, indicating that dichloropropene was not as effective as EDB for controlling sting nematodes. These findings are consistent with those recently reported by others workers (3, 5, 9).

Sting nematode control obtained in this experiment from row application of DBCP at 0.9 gallon per acre probably would not have been so prolonged had a lower application of 0.5 gallon per acre been used. This lower rate is now considered adequate in south Georgia for treating rows spaced 38 inches apart, but the important point is that possibly DBCP can be used to control nematodes for more than a single crop season, which may be of considerable importance in the production of perennial plants. Undoubtedly broadcast fumigation would have given as good or better control over a comparable period of time.

The data from this experiment indicate that under certain conditions nematocides that give nematode control throughout the season, or at least for the greater part of the growing season, will give larger yields than nematocides that control nematodes for only a short while early in the season. Heretofore, control has been considered adequate when the nematode populations are reduced initially to a level low enough for a crop to be grown without severe damage. Furthermore, soil fumigants have not generally been expected to control nematodes for longer than one growing season, but the data reported herein indicate that measurable control for certain materials may extend into the second crop-year. These findings suggest that much additional information is needed on soil fumigation, particularly with respect to specificity of chemicals for control of various nematode species, and to the duration of control.

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CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, NEMATOLOGY FIELD LABORATORY, TIFTON, GEORGIA

THE GEOGRAPHICAL DISTRIBUTION OF FIBER CONTAINING FLUORESCENT SPOTS ASSOCIATED WITH ASPERGILLUS FLAVUS IN THE UNITED STATES COTTON CROP OF 1957

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Abstract

A series of 4630 raw cotton classers' samples from the United States cotton crop of 1957 was examined under an ultra-violet lamp for the detection of the bright greenish-yellow fluorescent spots which have been shown in previous work to be associated with infection of the fiber by Aspergillus flavus. Of the samples received from the classing office at El Centro, California, 53.6 percent contained such spots; the next most frequent occurrences of the phenomenon were in cotton from the classing offices of Harlingen, Texas (31.2 percent), Dallas, Texas (9.7 percent), and Phoenix, Arizona (9.0 percent). Samples examined from other classing offices throughout the cotton belt showed very low percentages of such samples, or none.

In previous papers from this laboratory, it was reported that certain spots in raw cotton fiber which exhibit a characteristic bright greenish-yellow fluorescence under ultra-violet light are infected with the fungus Aspergillus flavus (2, 3). The fluorescent substance in these spots (designated "BGY" spots) in commercial cotton was shown by chromatographic means to be identical with a pigment produced when A. flavus was grown under appropriate pure-culture conditions on cotton fiber. Fibers from the naturally infected spots and from laboratory-incubated material were both found to show definite physical deterioration.

The present report pertains to the geographical distribution of fluorescent A. flavus spots in cotton of the United States crop of 1957. It supplements an earlier statement on the 1954 crop (3) which reads as follows: "To date, high percentages of samples containing BGY spots have been found from only two areas of United States production, namely, from the general region of Yuma, Arizona (including a nearby area in California around Blythe) and from the Brownsville-Harlingen area of Texas. Lower percentages of samples with BGY-fluorescent spots were noted from various other regions of Texas and very occasional samples with the same type spots from essentially all of the other United States producing areas."

The data here presented were obtained by examination of cotton classers' samples of the 1957 crop, identified according to grade and classing office, under a "Blak-Ray" long-wave ultra-violet lamp. The samples were in the form of the usual cotton classing standard samples, that is, in the shape of "loaves" or bats with an exposed surface of about 5 x 7 inches. They were examined only on the exposed surface, so that the numbers of samples actually containing BGY spots would undoubtedly have been found to be higher if the loaves had been torn apart and the fiber examined throughout. However, for comparative figures on geographical distribution the surface examination used was considered adequate. The samples contained numerous other fluorescent spots of various types in addition to the BGY spots. In a few cases it was impossible to distinguish BGY spots from other types of fluorescence, but these cases were sufficiently rare to be considered unimportant in affecting the conclusions arrived at and such samples were simply omitted from the calculations.

The data from the present work are presented in Tables 1 to 4, which show results with samples from the western, Texas-Oklahoma, mid-South, and southeastern areas of United States cotton production, respectively. It may be seen that the higher concentrations of the BGY spots were from the classing offices at El Centro, California (Table 1) and Harlingen, Texas (Table 2). There were relatively large numbers of BGY-fluorescent samples from classing offices at Dallas, Texas, and Phoenix, Arizona, and very small numbers from offices in other parts of the United States. The fluorescent spotting, then, appeared to be quite geographically localized in the 1957 crop and to occur especially in the same areas as were noted

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Table 1. Occurrence in western cotton of the 1957 crop of bright greenish-yellow fluorescent spots associated with the growth of Aspergillus flavus.

Grade and Classing office	Fluorescent samples/total samples examined						
	GM[a]	SM	M	SLM	LM	SGO	GO
White grades:							
Bakersfield, Calif.	0/10	0/10	0/20	0/20	0/20	0/19	0/4
Carlsbad, N. Mex.	0/14	0/15	0/19	0/19	0/15	0/22	0/9
El Centro, Calif.	10/11	5/10	6/20	5/20	15/20	11/19	---
Fresno, Calif.	0/10	0/10	0/20	0/20	0/20	0/29	---
Phoenix, Ariz.	0/14	1/14	2/24	2/24	4/24	3/20	3/10
Spotted and gray grades:							
Bakersfield, Calif.	0/6	0/22	0/22	0/35	0/10	---	---
Carlsbad, N. Mex.	0/3	0/9	0/5	0/9	0/4	---	---
El Centro, Calif.	---	26/38	20/38	2/13	12/20	---	---
Fresno, Calif.	0/19	1/29	0/36	0/40	0/18	---	---
Phoenix, Ariz.	---	0/28	0/29	2/29	4/18	---	---

[a]Abbreviations for grade designations as follows: GM, good middling; SM, strict middling; M, middling; SLM, strict low middling; LM, low middling; SGO, strict good ordinary; GO, good ordinary.

Table 2. Occurrence in Texas-Oklahoma cotton of the 1957 crop of bright greenish-yellow fluorescent spots associated with the growth of Aspergillus flavus.

Grade and Classing office	Fluorescent samples/total samples examined						
	GM[a]	SM	M	SLM	LM	SGO	GO
White grades:							
Abilene, Tex.	---	0/22	1/20	0/20	0/20	0/10	---
Altus, Okla.	0/4	0/11	0/11	0/5	0/21	---	0/2
Austin, Tex.	0/9	0/10	0/20	0/20	0/11	0/20	---
Corpus Christi, Tex.	0/10	0/10	0/20	2/20	1/32	0/20	2/6
Dallas, Tex.	0/9	1/11	4/22	4/23	2/12	1/17	---
El Paso, Tex.	0/14	0/14	0/14	0/14	0/14	0/14	---
Harlingen, Tex.	---	0/9	1/22	6/21	2/10	4/15	---
Lubbock, Tex.	0/4	0/10	0/10	0/21	0/21	0/14	---
Oklahoma City, Okla.	---	0/11	0/19	0/22	4/20	0/10	---
Pecos, Tex.	0/5	0/5	0/9	0/9	0/9	---	---
Spotted and gray grades:							
Abilene, Tex.	---	2/12	0/19	1/20	0/20	---	---
Altus, Okla.	---	0/12	0/29	1/20	0/20	---	---
Austin, Tex.	---	0/12	0/14	0/24	0/10	---	---
Corpus Christi, Tex.	---	0/10	3/22	2/10	3/10	---	---
Dallas, Tex.	1/3	3/14	3/36	2/46	0/24	---	---
El Paso, Tex.	0/3	0/7	0/7	0/8	0/6	---	---
Harlingen, Tex.	---	2/5	9/14	7/8	3/5	---	---
Lubbock, Tex.	---	0/10	0/23	0/20	1/22	---	---
Oklahoma City, Okla.	---	1/16	0/30	0/16	0/21	---	---
Pecos, Tex.	0/3	0/4	0/5	0/5	---	---	---

[a]See footnote, Table 1.

Table 3. Occurrence in mid-South cotton of the 1957 crop of bright greenish-yellow fluorescent spots associated with the growth of Aspergillus flavus.

Grade and Classing office	Fluorescent samples/total samples examined						
	GM[a]	SM	M	SLM	LM	SGO	GO
White grades:							
Alexandria, La.	---	---	0/25	0/20	0/10	0/20	0/4
Blytheville, Ark.	0/10	0/10	0/20	0/10	0/20	0/5	---
Greenwood, Miss.	0/4	0/20	0/20	0/12	0/20	0/20	0/7
Hayti, Mo.	---	0/10	0/21	0/21	0/11	0/10	---
Jackson, Miss.	---	1/11	0/26	0/21	0/21	0/10	---
Little Rock, Ark.	0/10	0/20	0/21	0/11	0/22	0/21	0/7
Memphis, Tenn.	0/10	0/11	0/22	0/23	0/22	0/21	---
Winnsboro, La.	0/4	1/5	0/10	0/10	0/10	0/9	---
Spotted and gray grades:							
Alexandria, La.	---	0/10	0/4	2/21	0/20	---	---
Blytheville, Ark.	---	0/19	0/30	0/20	0/20	---	---
Greenwood, Miss.	---	0/22	1/26	0/20	0/20	---	---
Hayti, Mo.	---	0/23	1/22	0/21	0/20	---	---
Jackson, Miss.	---	0/5	0/5	0/10	0/10	---	---
Little Rock, Ark.	---	0/19	0/10	0/21	0/22	---	---
Memphis, Tenn.	---	0/11	1/31	0/10	0/22	---	---
Winnsboro, La.	---	0/13	0/14	0/10	0/10	---	---

[a]See footnote, Table 1.

Table 4. Occurrence in southeastern cotton of the 1957 crop of bright greenish-yellow fluorescent spots associated with the growth of Aspergillus flavus.

Grade and Classing office	Fluorescent samples/total samples examined						
	GM[a]	SM	M	SLM	LM	SGO	GO
White grades:							
Atlanta, Ga.	---	0/10	0/18	0/10	0/30	1/17	---
Augusta, Ga.	---	0/10	0/19	0/20	0/10	1/12	0/10
Birmingham, Ala.	0/7	---	0/19	2/20	1/21	0/10	0/12
Columbia, S. Car.	---	0/10	0/19	0/20	0/10	0/13	0/4
Montgomery, Ala.	---	---	0/14	0/20	0/14	0/10	0/10
Raleigh, N. Car.	0/4	0/10	0/12	0/14	0/14	1/14	0/4
Spotted and gray grades:							
Atlanta, Ga.	---	0/14	0/38	0/21	0/10	---	---
Augusta, Ga.	---	0/11	0/29	0/29	0/21	---	---
Birmingham, Ala.	---	0/12	0/29	0/37	0/20	---	---
Columbia, S. Car.	---	0/19	0/35	2/30	1/20	---	---
Montgomery, Ala.	---	0/10	0/14	0/12	0/14	---	---
Raleigh, N. Car.	---	---	0/13	0/16	0/8	---	---

[a]See footnote, Table 1.

earlier for the 1954 crop. (El Centro and Blythe, California, and Yuma, Arizona, are close to each other.) Table 5 summarizes the data of Tables 1 to 4. The territories served by the individual classing offices are detailed in a recent publication (1). The distribution of A. flavus in soils and on other substrates of various kinds is thought to include the total area of cotton production in the United States; the geographical localization of the fluorescence phenomenon in the particular areas to which it seems to be largely confined is still not understood, although it has been noted that the two areas where BGY incidence was high are ones of exceptionally high temperatures at the time when cotton bolls are opening.

Table 5. Summary of occurrence in cotton of the 1957 United States cotton crop of bright greenish-yellow fluorescent spots associated with the growth of Aspergillus flavus.

Classing office	Percentage of samples showing BGY-fluorescence
Western	
Bakersfield, Calif.	0.0
Carlsbad, N. Mex.	0.0
El Centro, Calif.	53.6
Fresno, Calif.	0.4
Phoenix, Ariz.	9.0
Texas-Oklahoma	
Abilene, Tex.	2.4
Altus, Okla.	0.7
Austin, Tex.	0.0
Corpus Christi, Tex.	7.6
Dallas, Tex.	9.7
El Paso, Tex.	0.0
Harlingen, Tex.	31.2
Lubbock, Tex.	0.6
Oklahoma City, Okla.	3.0
Pecos, Tex.	0.0
Mid-South	
Alexandria, La.	1.5
Blytheville, Ark.	0.0
Greenwood, Miss.	0.5
Hayti, Mo.	0.6
Jackson, Miss.	0.8
Little Rock, Ark.	0.0
Memphis, Tenn.	0.5
Winnsboro, La.	1.0
Southeastern	
Atlanta, Ga.	0.6
Augusta, Ga.	0.6
Birmingham, Ala.	1.6
Columbia, S. Car.	1.7
Montgomery, Ala.	0.0
Raleigh, N. Car.	0.9

Acknowledgment: Thanks for the opportunity to examine the samples concerned in this study are expressed to the Cotton Division, Agricultural Marketing Service, United States Department of Agriculture, Washington, D. C. The samples were a part of a cotton grade survey carried out in the Agricultural Marketing Service grade standards studies.

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CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

FIELD SCREENING OF VARIOUS FUNGICIDES FOR CONTROL OF COTTON SEEDLING DAMPING-OFF[1]

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Abstract

Significant differences between treated and nontreated plots with PCNB plus captan showed the most promise for controlling cotton seedling damping-off in one of three field tests in 1957. Tests were more successful in 1958, with significantly improved stands resulting from the application of various fungicides in three out of four field experiments. The treatments showing the most promise were: PCNB plus captan plus zineb; captan plus zineb; PCNB plus captan; PCNB plus dichlone; PCNB plus nabam and calcium chloride plus nabam. Mylone tended to be phytotoxic in both 1957 and 1958 field tests. These results in general are comparable to data from preliminary greenhouse screening tests.

INTRODUCTION

Cotton damping-off has been recognized as an important seedling disease of cotton since 1892 (1). Damping-off occurs in every cotton growing area of Louisiana and is the one disease that has caused, in recent years, the largest estimated loss of cotton in the South (4). The organism most frequently isolated from diseased seedlings in Louisiana has been Rhizoctonia solani Kuehn and recent reports from other States show that species of Pythium and Fusarium may be important pathogens in a damping-off complex (3, 6).

Various chemicals have been screened in the laboratory and greenhouse (8, 9) and those materials which have shown the most promise were tested further under field conditions. This progress report gives results of field studies conducted in 1957 and 1958.

FIELD TRIALS

There were three field tests run at two locations in 1957: two tests at the Northeast Louisiana Experiment Station at St. Joseph and one at the Barrett plantation near Roosevelt. In the first experiment at St. Joseph a randomized, replicated block design was used. The treatments were[3]: PCNB plus mylone (3,5-dimethyltetrahydro-1,3-5,2H thiadiazine-2-thione); PCNB plus captan; PCNB plus nabam; nabam plus zinc sulfate; nabam plus mylone; nabam plus zinc omadine (zinc salt of 2-pyridinethione 1-oxide); captan plus mylone; captan plus zinc omadine; and a nontreated check. These fungicides were applied as liquid in-the-furrow treatments at the time of and as a part of the planting operation at rates of 5 pounds per acre for wettable powders and 4 quarts per acre for the liquid fungicides, commercial formulations, indicated in footnote 1. Where two fungicides were used in the same treatment, half of these amounts were used of each material. Stand and disease counts were made of the plants while still in the seedling stage. Seed cotton yield data were taken for the first St. Joseph test and recorded in pounds per acre for each treatment.

[1]Acknowledgments: Appreciation is expressed to Dr. A. G. Plakidas, Pathologist, for reading the manuscript; to Mr. A. M. Hillis of the Olin-Mathieson Chemical Corp. and Mr. R. Blondeau of the Shell Oil Co. for their assistance in some of the field work. Appreciation is also expressed to the following companies for providing the chemicals indicated: Olin-Mathieson Chemical Co. (PCNB 75WP and zinc omadine 50WP); Stauffer Chemical Co. (captan 50WP); Carbide and Carbon Chemical Co. (mylone 85WP); Rohm and Haas Co. (nabam, zinc sulfate, and zineb 65WP); U. S. Rubber Co. (dichlone 50WP); and Shell Oil Co. (SD-4741).

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[3]The chemical composition of fungicides with recognized coined names (5, 10) is not given; the chemical composition of materials with code numbers was not known.

In the second experiment at St. Joseph, four fungicides were applied alone or in combinations as dusts in-the-furrow treatments[4]. The figures in parentheses indicate the rates of application, pounds per acre, of each of the materials used: 20 percent PCNB (14.3); 10 percent dichlone (4.7); 15 percent PCNB plus 10 percent dichlone (9.5); 18 percent PCNB plus 5 percent zinc omadine (18.9); and a nontreated check. While the plants were in the seedling stage, stand and disease counts were made by taking readings from randomly selected 10-foot plots within each treatment. A skip count was also taken.

The field trial at Roosevelt was in a split-plot design with the following fungicides applied as liquid in-the-furrow treatments at rates similar to those of the first St. Joseph test: PCNB plus mylone; PCNB plus captan; nabam plus mylone; nabam plus zinc sulfate; and a nontreated check.

During the spring of 1958 there were four field tests run at widely scattered points over the State: the Perkins Road Farm, Baton Rouge; the Northeast Louisiana Experiment Station, St. Joseph; the North Louisiana Hill Farm Experiment Station, Homer; and the Knight Plantation at Gayles. All plots consisted of randomized, replicated blocks.

Fungicides for the first three tests were applied as liquid in-the-furrow treatments using the commercial formulations indicated in footnote 1 with rates on a pounds or quarts per acre basis as indicated in parentheses. The Baton Rouge test consisted of five treatments: PCNB (1.5) plus captan (1.5) plus zineb (2); SD-4741-A (12); SD-4741-B (3); SD-4741-A (12) plus nabam (2); and a nontreated check. The St. Joseph test included six treatments and a nontreated check: PCNB (1.5) plus captan (1.5) plus zineb (2); PCNB (2.5) plus nabam (2); dichlone (5); PCNB (2.5) plus mylone (2.5); nabam (4) plus calcium chloride (10); and captan (2.5) plus zineb (2.5). Treatments at Homer were: PCNB (1.5) plus captan (1.5) plus zineb (2); PCNB (2.5) plus nabam (2); PCNB (2.5) plus dichlone (2.5); PCNB (2.5) plus captan (2.5); dichlone (5); PCNB (2.5) plus mylone (2.5); and a nontreated check.

The fourth test, located at Gayles, consisted of five treatments applied as in-the-furrow dusts using equipment similar to that used in 1957. The following materials were applied as treatments at a rate of 10.8 pounds per acre: 10 percent PCNB plus 10 percent captan; 14 percent PCNB plus 7 percent mylone; 7.1 percent PCNB plus 4.7 percent captan plus 8.2 percent zineb; 15 percent PCNB plus 10 percent dichlone; and a nontreated check.

While the plants were in the seedling stage, 2 to 3 weeks after planting and treating, stand counts were made at all locations based on the number of healthy plants in 100 feet of row. The number of hills in 100 feet of row were recorded for the St. Joseph plot. Two-row planters were used at all locations except Gayles, where a 4-row planter was used. Stand counts at this location were made on the middle two rows.

FIELD RESULTS

In 1957 there were no significant differences between the treated and nontreated plots in either of the two tests at St. Joseph (Table 1), and at Roosevelt only captan plus zinc omadine failed to give a significant response when compared with the nontreated check. At the latter location combinations of PCNB plus captan; PCNB plus mylone; and nabam plus zinc sulfate gave means significantly higher than the nontreated check.

Results from the 1958 field trials were generally more successful than in 1957 (Table 2). At St. Joseph means for stand counts showed that all treatments except dichlone alone and PCNB plus mylone were significantly higher than those of the nontreated plots. The highest counts were from PCNB plus nabam and PCNB plus captan plus zineb treated plots. The number of hills in the treated plot at St. Joseph were all significantly higher than those of the nontreated plots.

At Homer, there was no significant difference among treatments in comparison with the nontreated plots except for three treatments that were significantly lower. These were PCNB plus nabam, PCNB plus mylone, and dichlone alone. Since there was little, if any, damping-off at this location, some phytotoxicity in these three treatments was indicated.

At Baton Rouge wide differences were noted for the stand count means between all the treatments and the nontreated plots, but these differences were not statistically significant.

All treatment means for stand count at Gayles were significantly higher than those of the nontreated plot, with the combination of PCNB plus captan plus zineb showing the greatest difference.

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[4]The equipment used for application of the fungicide dusts was manufactured by the Gustafson Manufacturing Co. and provided by the Olin-Mathieson Chemical Co.

Table 1. Treatment means based on 100 feet of row for data and location indicated from field trials testing effects of various fungicides on control of cotton seedling damping-off, 1957.

Treatment	St. Joseph I			St. Joseph II			Roosevelt
	Stand	Disease	Y^{sc}/a[a]	Stand	Disease	Skip	Stand
PCNB				99.0	13.0	14.7	
Dichlone				111.0	32.0	14.2	
PCNB + dichlone				117.8	15.5	12.0	
PCNB + zinc omadine				110.3	19.5	10.7	
PCNB + mylone	136.5	9.8	476.5				28.5
PCNB + captan	140.5	11.3	403.0	112.5	6.8	12.7	42.1
PCNB + nabam	139.5	14.5	453.8				
Nabam + zinc sulfate	131.0	11.8	435.5				25.8
Nabam + mylone	148.0	17.0	495.5				18.6
Nabam + zinc omadine	133.5	22.3	443.8				
Captan + mylone	134.3	17.8	416.5				
Captan + zinc omadine	135.6	13.2	452.0				
Check	122.8	13.2	430.3	107.8	24.3	17.0	14.0
LSD .05	ns	ns	ns	ns	ns	ns	7.1
LSD .01	ns	ns	ns	ns	ns	ns	ns

[a] Y^{sc}/a = yield of seed cotton per acre.

Table 2. Treatment means based on 100 feet of row for data and location indicated from field trials testing effects of various fungicides on control of cotton seedling damping-off, 1958.

Treatment	St. Joseph		Homer	Baton Rouge	Gayles
	Stand	No. Hills	Stand	Stand	Stand
Dichlone	253	75	338		
PCNB + dichlone			372		598
PCNB + mylone	289	84	143		500
PCNB + captan			366		518
PCNB + nabam	392	83	318		
PCNB + captan + zineb	389	87	375	401	656
Nabam + CaCl	316	80			
Captan + zineb	348	84	394		
SD 4741-A				477	
SD 4741-B				378	
SD 4741-A + nabam				463	
Nontreated check	272	71	380	280	225
LSD .05	15	3	14	ns	60
LSD .01	20	4	18	ns	83

SUMMARY AND CONCLUSIONS

Results from the 1957 field tests at St. Joseph gave little information on chemical control of cotton seedling damping-off since there were no significant differences among any of the treatments. However, significant differences at the .05 level were obtained among treatments in the 1957 Roosevelt planting. In this test mylone tended to be phytotoxic and the combination of PCNB plus captan gave promise for controlling cotton seedling damping-off.

In 1958, the field results were much more promising with improved stand counts resulting from certain fungicide treatments included in three out of four field tests. Those treatments showing the most promise were PCNB plus captan plus zineb; captan plus zineb; PCNB plus captan; PCNB plus dichlone; PCNB plus nabam and nabam plus calcium chloride. Mylone tended to be phytotoxic in both the 1957 and 1958 tests. PCNB plus dichlone gave a higher stand count than when dichlone was used alone. Results from 1957 and 1958 field tests are comparable to data from preliminary greenhouse screening tests (8, 9). It was noted that fungicides applied as in-the-furrow dusts as a part of the planting operation tended to give better results than liquid in-the-furrow treatments. Some of these data are in agreement with the results of Bird et al. (2) and Ranney and Bird (6, 7).

Further field testing is necessary before specific recommendations can be made.

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LOUISIANA AGRICULTURAL EXPERIMENT STATION, BATON ROUGE

RELATION OF SOIL TEXTURE AND OCCURRENCE OF ROOT ROT DISEASE (SCLEROTIUM ROLFSII SACC.) OF PEANUT[1]

H. D. Dubey[2]

The peanut crop (Arachis hypogaea L.) was grown at several places at the Deochanda Experiment Station in 1956 and in each location it was found to be attacked by root rot disease caused by the fungus Sclerotium rolfsii Sacc. However, the disease was much more prevalent in two fields (Demonstration and Peanut Experimental Plots) than in other affected fields. Since the crop in all fields was grown under similar conditions of fertilization and culture and planted with the same seed stock it appeared that the probable cause for the high incidence of the disease in these two fields was edaphic in nature. To ascertain whether this was the case soil samples from the two highly affected fields and from one lightly affected field (Broadbased Terrace) were analyzed for the factors given in Tables 1 and 2.

Determination of sand, silt and clay was done by mechanical analysis (7). Water holding capacity was estimated by determining the amount of water needed to saturate the soil to field capacity. Microorganisms were counted by the usual plate method using nutrient agar medium for bacteria and potato-dextrose agar medium for fungi. Reaction of the medium was maintained at pH 7. The plates were incubated for 48 hours at 32° C before actual counts were made. Organic carbon was estimated by Walkley's method (11), while total nitrogen was determined by Kjeldahl's method modified by Gunnings (1). Available phosphate was determined by the method indicated by Peach et al. (8). Potassium estimation was done by the cobaltinitrite method (9). Calcium carbonate was estimated by the rapid titration method (9). The pH was determined by the electromatic method using glass electrodes.

Table 1. Percentage of disease incidence, and physical and microbiological analyses of soils in fields heavily and lightly infected with sclerotial root rot disease of peanut.

Field	Disease incidence (percent)	Physical composition of soil (percent)				Microbial population	
		Sand	Silt	Clay	Water holding capacity	Fungi per gram of soil	Bacteria per gram of soil
Demonstration Plot	70	80.3	7.3	12.4	29.1	85,000	90,000
Peanut Exp. Plot	65	79.4	9.0	11.6	25.4	70,000	120,000
Broadbased Terrace	30	67.2	8.9	23.9	38.5	20,000	75,000

Table 1 shows that the soils of the highly affected Demonstration and Peanut Experimental Plots are high in sand and low in clay as compared with the soil of the Broadbased Terrace field. As most soil-borne diseases have been shown to be favored by light textured soils (3, 4, 6, 10), it appears that the light sandy soils of these two highly affected fields provided favorable soil aeration for the activity of the strongly aerobic fungal pathogen, Sclerotium rolfsii, and thus led to the high incidence of the disease in these two fields. The relatively low incidence of the disease in the Broadbased Terrace field may, by the same reasoning, be attributed to the heavier texture of the soil of that field.

The fungal population and the severity of the disease both appear to increase in the sandy soils of the Demonstration and Peanut Experimental fields (Table 1), and thus the fungal population seems to be correlated with the incidence of the root rot disease of peanut in the soil. This observation is in conformity with the findings of Reinking (10).

A perusal of the chemical analysis data in Table 2 indicates the existence of a negative correlation between nitrogen content of the soil and disease occurrence, and a positive correlation between phosphorus content and disease occurrence. Similar observations were made

1 Contribution from the Deochanda Experiment Station, Damodar Valley Corporation, Hazaribagh, Bihar, India. The author expresses his thanks to Dr. P. Sen, Director of Soil Conservation Department, for encouragement, and Mr. R. K. Asthana, Soils Laboratory, for physical and chemical analyses of the soil samples.

2 Formerly Research Assistant at the Deochanda Experiment Station, now graduate student in agronomy at the University of Georgia.

Table 2. Percentage of disease incidence and chemical analysis of soils in fields heavily and lightly infected with sclerotial root rot disease of peanut.

Field	Disease incidence (percent)	Chemical composition of soil					
		Organic carbon (percent)	Total nitrogen (percent)	Available phosphate ppm	Available potash (percent)	Calcium carbonate (percent)	pH
Demonstration Plot	70	0.21	0.043	8.5	0.025	0.25	5.6
Peanut Exp. Plot	65	0.23	0.048	11.5	0.039	0.25	5.7
Broadbased Terrace	30	0.42	0.066	5.1	0.033	0.75	5.5

by Blank (2) and Jordan et al. (5) with cotton root rot in Texas. The latter also observed that the opposing effects of nitrogen and phosphorus on the occurrence of the disease was more intensified in light sandy loams, and less striking on heavier soils. The light sandy texture of the highly affected fields in this case, too, may have played a similar role.

Presence of high percentage of organic material (Table 2) in the Broadbased Terrace field appears to be instrumental in inhibiting the activity and development of the soil microorganisms in general and the fungal population in particular by increasing the concentration of carbon dioxide in the micro-atmosphere around the roots (4). The heavier texture of this soil may have contributed in the poor aeration by causing hindrance to rapid gaseous exchange between the soil and atmosphere.

The occurrence of the disease does not appear to be related to potash and calcium carbonate content, and the pH of the soil. The difference in the calcium carbonate content of the soil samples may be inherent in the method employed for its determination.

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DAMPING-OFF AND THREAD BLIGHTS OF COFFEE IN EL SALVADOR[1]

George F. Weber and Leopoldo Abrego[2]

Abstract

New disease manifestations on coffee seedlings in seed beds, caused by Rhizoctonia solani, are described and illustrated. Damping-off of coffee seedlings by Corticium rolfsii is reported for the first time. Silky thread blight of coffee caused by Rhizoctonia ramicola is reported and illustrated for the first time, and cultural characteristics of Corticium koleroga are compared with each of the above.

Damping-off of seedlings in various stages of their development, caused by Rhizoctonia solani Kuehn, is common and generally recognized (Fig. 1). This disease as it occurs on coffee seedlings has manifested a series of conditions in addition to the typical dark chocolate brown lesions appearing on the stems at the soil line and usually extending upward more rapidly than downward. Seedlings in their youngest stages usually wilt, the cotyledons and upper portions bend over but the lower stem remains erect.

Frequently, however, seedlings escape infection at the soil line and continue to develop normally until a lesion develops an inch or more above the soil line and rapidly becomes similar to the condition observed at the soil line. Close examination reveals the typical brown hyphae of the fungus on the stem from the soil line to the lesion. These stem lesions are found less frequently than the soil line lesions.

Seedlings that have escaped stem infection frequently show lesions on the cotyledons, usually at the place where the blade joins the petiole, but not always so since early infections may occur along the margins or at various places on the cotyledon blades. The diseased areas on the cotyledons are a dark chocolate brown and expand rapidly until the cotyledons are completely involved. They dry rapidly and remain attached to the stem, which remains erect.

Coffee seed are planted closely, and consequently the seedlings in the cotyledon stage are crowded to such an extent that they are in close contact (Fig. 2). This condition affords adequate means for the mycelium of the fungus to grow from a plant with diseased cotyledons to those on either side of it. Under favorable moisture and temperature the fungus spreads rapidly from plant to plant along the rows involving all cotyledons as it progresses, showing no contact with the soil except the original ascent on a single plant. Frequently the basidial stage, Pellicularia filamentosa (Pat.) Rogers [sometimes erroneously referred to in the past as Corticium vagum Berk. & Curt.], of the fungus develops on the lower surface of partially killed cotyledons, producing typical basidiospores in abundance. This sproulating area does not wet easily. Upon microscopical examination, drops of water rolling over it revealed a load of basidiospores. In most instances the cotyledons, terminal shoot and axillary buds are killed and the seedling dies, turns dark brown and remains more or less erect (Fig. 3). When conditions are less favorable for the development of the disease in the previously described stages or when the seedling has escaped severe infection, it survives and produces the first and second whorls of true leaves. At this time the fungus previously not conspicuous may invade the stem or leaves of the plant above the cotyledon scars and kill the seedling from the top down. A 50 percent loss of seedlings from these manifestations of the disease has been observed, almost half of which was from cotyledon invasion by contact with adjacent plants.

Corticium rolfsii Curzi [Pellicularia rolfsii (Curzi) E. West] was isolated from young coffee seedlings showing a damping-off disease. The symptoms, however, were somewhat different from those resulting from invasion of the stem tissue by Rhizoctonia solani, as described previously. The fungus attacked the seedlings at the soil line, girdling them and producing a light tan color of the invaded tissue above the soil line and below the cotyledons. This area appeared more or less water-soaked and the tan color blended in marginal areas into the normal green of the uninvaded parts. There was only scanty hyphal growth on the outside of the

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[2]Respectively, Special Technician and Chief, Department of Plant Pathology, Instituto Salvadoreno de Investigaciones del Cafe, Santa Tecla, El Salvador.

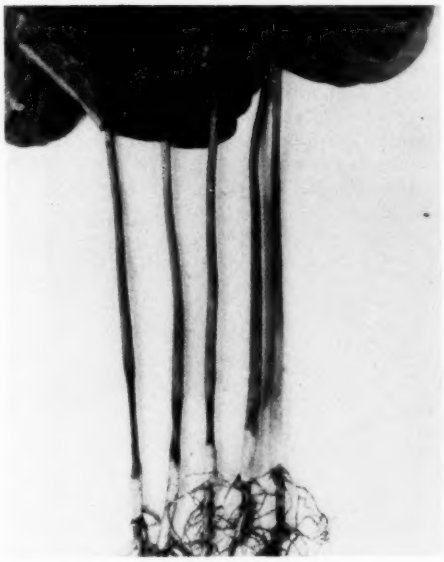

FIGURE 1. Coffee seedlings showing soil line damping-off lesions in various stages of development, caused by Rhizoctonia solani.

FIGURE 2. Crowded coffee seedlings in seed bed, and damping-off disease.

FIGURE 3. Coffee seedlings from seed bed showing aerial type of injury to cotyledons through contact rather than from the soil.

FIGURE 4. Damping-off of coffee seedlings caused by Corticium rolfsii.

host tissue above the soil line. The characteristic white mycelium was observed growing from the stem of the seedlings into the surrounding soil (Fig. 4). Several white immature sclerotia were located on the stem at the soil surface. Plantings of the diseased tissue were made on poured hard potato-dextrose agar plates, from which the characteristic mycelium and sclerotia of the fungus developed. The disease was not generally prevalent in the area although common in seed beds to which organic compost had been added as a surface dressing. The compost apparently was the medium through which the seed bed became inoculated. A preliminary examination of the available literature failed to reveal any previous report of the parasitizing of coffee by this fungus.

FIGURE 5. Silky thread blight on coffee showing light colored mycelium on older leaves and miniature mycelial wefts where leaves touch each other and at base of petiole.

Control of the disease should be obtained by the application of usual sanitary practices as applied to proper composting, soil disinfection, and the application of an organic mercury to the seedlings where the disease is common and widely scattered. If rather scarce and observed early, diseased seedlings and surrounding surface soil should be carefully removed and the area treated with a disinfectant, and the removed soil replaced with new soil.

Rhizoctonia ramicola D. A. Roberts & G. F. Weber, causing silky thread blight on many ornamental perennials, was observed for the first time causing considerable defoliation and fruit infection on coffee plants. The disease is recognized on coffee by the off-color and spotting of the foliage, which later becomes brown and remains weakly attached by the fungus hyphae to the host tissue. The leaves on long free-growing stems are usually shed because the aerial hyphae are unable to hold them, while leaves more or less protected by numerous thick-growing branches remain attached to the stems by the very fine silky hyphae that are almost invisible on the cortical surfaces of the internodal spaces (Fig. 5), in contrast to the coarse strands of most thread blights. At the nodes, however, there is an accumulation of light-colored hyphae forming a dense weft readily visible growing across the space between the main stem and the base of the petiole. The fungus is very easily overlooked and requires very close inspection. There are no thread-like strands as produced by Corticium koleroga (Cke.) Hoehn. [Pellicularia koleroga Cke.] on the lower surfaces of twigs and branches, but rather a very sparse network of hyphae. No sclerotia have been found. Cultures of the fungus from coffee on potato-dextrose agar are sterile. It is rapid growing, pale tan, concentrically zoned, and readily distinguished from the other related fungi found on this host.

Control should be by spraying with any of the currently recommended fungicides.

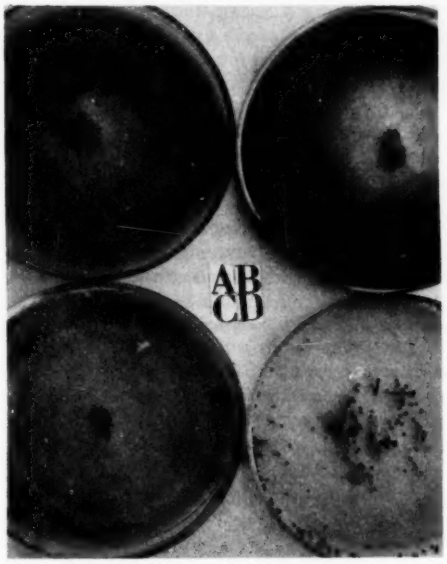

FIGURE 6. Potato-dextrose agar plate cultures of (a) Corticium koleroga, (b) Pellicularia filamentosa, (c) Rhizoctonia ramicola, and (d) Corticium rolfsii.

Corticium koleroga continues to be of first importance as a parasitic fungus on coffee. Symptoms of this disease are well known. It is mostly characterized by the white to brown hyphal threads, the manner of leaf invasion, and the lack of sclerotial formation. In nature this aerial thread blight is readily distinguished from the aerial silky thread blight, but in culture the fungi are very similar in appearance and neither produces sclerotia on artificial agar or on the host, thus readily separating them from the soil inhabiting fungi causing damping-off (Fig. 6). This thread blight disease is common and widespread, and during the rainy season causes considerable damage by killing foliage and infecting berries, resulting in the shedding of both, and continues to be particularly important in relation to the production of fruit during the following year. Plants heavily defoliated produce a smaller crop of fruit the following year. New control information is needed to reduce losses from this disease.

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RESULTS OF REGIONAL SEED-TREATMENT TESTS FOR THE CONTROL OF SEED-BORNE AND SOIL-BORNE COMMON BUNT OF WINTER WHEAT IN THE PACIFIC NORTHWEST, 1958[1]

Laurence H. Purdy[2]

Summary

Twenty-six different chemical formulations were tested as seed-treatment fungicides for the control of common bunt of winter wheat in the Pacific Northwest. Eight plots were established in Idaho, Montana, Oregon, Utah, and Washington. Included in the tests were 13 mercurials, 8 formulations of hexachlorobenzene, 3 formulations of pentachloronitrobenzene, and 2 other non-mercurials. Data were obtained from seven of the eight locations. The results at all seven locations were similar.

Good control of seed-borne bunt was obtained with most materials tested. Formulations of hexachlorobenzene when used as seed treatments controlled bunt originating from soil-borne spores. Two of the three pentachloronitrobenzene formulations tested also provided satisfactory control. The mercurials, as in previous tests, failed to control bunt that originated from soil-borne inoculum.

INTRODUCTION

Regional seed-treatment tests for the control of seed-borne and soil-borne common bunt of winter wheat (Tilletia caries (DC.) Tul. and T. foetida (Wallr.) Liro) in the Pacific Northwest were carried out in 1958 as a continuation of tests begun in 1954. The results from these tests serve as a basis for measuring the stability of the different formulations and the active ingredients of the various fungicides used for bunt control in this region and for evaluation of new products. Continued good performance on a regional basis is essential for a fungicide to qualify as a recommended material for bunt control. Most of the materials tested in 1958 are of immediate commercial interest. A few experimental formulations were included because of their previous good performance in screening tests.

MATERIALS AND METHODS

Twenty-six different chemical formulations were tested at eight locations[3] in the Pacific Northwest in Idaho, Oregon, Montana, Utah, and Washington. The materials tested, along with their active ingredients as reported by the manufacturers, whose names also are listed, are as follows:

Anticarie -- 40 percent hexachlorobenzene. H. P. Rossiger Company, Inc.
Cal. Spray 80 percent HCB -- 80 percent hexachlorobenzene. California Spray-Chemical Corp.
Chemagro C-272 -- 20 percent wettable powder, composition unknown. Chemagro Corp.
Chemagro D-113 -- 20 percent wettable powder, composition unknown. Chemagro Corp.
Ceresan M -- 7.7 percent N-(ethylmercuri)-p-toluenesulfonanilide. E. I. du Pont de

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[1]Cooperative investigations of the Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and the Agricultural Experiment Stations of Idaho, Montana, Oregon, Utah, and Washington. Scientific Paper No. 1793, Washington Agricultural Experiment Station, Pullman, Washington.

[2]Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, Pullman, Washington.

[3]Grateful acknowledgment is extended to the cooperators at the indicated locations who assisted in these tests: Bozeman, Montana (Dr. E. R. Hehn); Kalispell, Montana (W. W. Mauritson and V. R. Stewart); Moscow, Idaho (Dr. A. M. Finley); Worley, Idaho (E. W. Bitters); Moro, Oregon (W. E. Hall); Pendleton, Oregon (Dr. C. R. Rhode); Logan, Utah (Dr. W. G. Dewey); Lind, Washington (W. L. Nelson).

Nemours & Co.
Ceresan 75 -- 2.80 percent ethylmercury 2,3-dihydroxypropyl mercaptide and 0.60 percent ethylmercury acetate. E. I. du Pont de Nemours & Co.
Ceresan 100 -- 3.10 percent ethylmercury 2,3-dihydroxypropyl mercaptide and 0.67 percent ethylmercury acetate. E. I. du Pont de Nemours & Co.
Ceresan 200 -- 6.00 percent ethylmercury 2,3-dihydroxypropyl mercaptide and 1.30 percent ethylmercury acetate. E. I. du Pont de Nemours & Co.
Emmi (liquid) -- 10.34 percent 1,4,5,6,7,7-hexachloro-N-(ethylmercuri) bicyclo (2.2.1) hept 5-ene-2,3-dicarboximide. Velsicol Corp.
Emmi (powder) -- 10 percent active ingredient. Velsicol Corp.
Mema -- 11.4 percent 2-methoxyethylmercury acetate. Chipman Chemical Co.
Monsanto Liquid PCNB -- ? percent pentachloronitrobenzene. Monsanto Chemical Co.
No Bunt 40 -- 40 percent hexachlorobenzene. Chipman Chemical Co.
No Bunt 80 -- 80 percent hexachlorobenzene. Chipman Chemical Co.
Ortho LM Seed Protectant -- 2.4 percent methylmercury 8-hydroxyquinolate. California Spray-Chemical Corp.
Ortho LM 42 (OR-838) and (OR-839) -- 4.2 percent mercury. California Spray-Chemical Corp.
Ortho LM - Heptachlor -- 0.96 percent methylmercury 8-hydroxyquinolate and 37.9 percent heptachlor. California Spray-Chemical Corp.
Panogen 15 -- 2.2 percent cyano (methylmercury) guanidine. Panogen, Inc.
Panogen 42 -- 6.3 percent cyano (methylmercury) guanidine. Panogen, Inc.
Sanocide -- 40 percent hexachlorobenzene. California Spray-Chemical Corp.
Smut Go 40 -- 40 percent hexachlorobenzene. Miller Products Co.
Smut Go 80 -- 80 percent hexachlorobenzene. Miller Products Co.
Stauffer HCB-40 -- 40 percent hexachlorobenzene. Stauffer Chemical Co.
Terraclor -- 75 percent pentachloronitrobenzene. Mathieson Chemical Corp.
Terraclor Liquid -- ? percent pentachloronitrobenzene. Mathieson Chemical Corp.

Seed of the winter wheat variety Orin, inoculated with bunt spores at the rate of 1/2 gram of spores per 100 ml of seed, was used at all locations. Where soil-borne inoculum was used, the spores were applied to the open furrows at the rate of 1 gram of spores per 10 feet of row.

The seed was treated in units of 250 ml by the method described in a previous report[4]. Treated seed was planted in randomized 10-foot rows with three replications of each treatment at each location. The effectiveness of the various treatments was measured by the percentage of infected heads, based on the total number of heads per row. Calculations of percentages and statistical analyses of the data were made by the Computing Center of the State College of Washington.

Statistical significance at the 5 percent level is indicated in the columns so titled in Tables 1, 2, and 3. Treatments that are within the limits of an individual line do not differ significantly from each other, but treatments outside the limits of that line differ significantly from the treatments enclosed by it.

RESULTS

Significant results were obtained from seven of the eight nurseries. Because of unfavorable environmental conditions for infection, bunt failed to develop in the nursery at Bozeman, Montana. The data from the other seven locations showed a similar pattern, and for this reason analyses were based on the averages from all locations. Summaries of results for the control of seed-borne, soil-borne, and seed-borne plus soil-borne bunt, respectively, are presented in Tables 1, 2, and 3.

High percentages of bunt developed in the untreated check rows of all plots. In the tests for the control of bunt developing from seed-borne spores, 82.2 percent bunt developed in the untreated check rows (Table 1). Good control was obtained with all the standard treatments, whereas only fair control was provided by Chemagro C-272, Monsanto Liquid PCNB, and Stauffer HCB-40. Inadequate control was obtained with Terraclor Liquid and Ortho LM plus Heptachlor. The standard treatments referred to here are fungicides that have provided good control in previous tests and for the most part are recommended in the Northwest for bunt control

[4]Purdy, L. H. 1955. Regional seed treatment tests for the control of seed-borne and soil-borne common smut of winter wheat in the Pacific Northwest. Plant Disease Reptr. 39: 844-849.

Table 1. Summary of results from seven regional seed-treatment tests for the control of seed-borne common bunt in winter wheat in the Pacific Northwest, 1958.

Treatment	Form[a]	Ounces per bushel	Mean percentage of bunt	Statistical Significance
Check - untreated			82.2	
Ortho LM + Heptachlor	L	1	37.2	
Terraclor Liquid	L	2-1/4	20.2	
Stauffer HCB-40	W	1	10.2	
Monsanto Liquid PCNB	L	2-1/4	8.9	
Chemagro C-272	W	2	7.0	
Terraclor	W	1	4.1	
Chemagro D-113	W	2	3.6	
Smut Go 40	W	1	3.0	
No Bunt 80	W	1/2	2.8	
Cal. Spray 80% HCB	W	1/2	1.9	
Mema	L	1/4	1.1	
Anticarie	W	1	0.8	
Ortho LN	L	3/4	0.7	
Smut Go 80	W	1/2	0.7	
No Bunt 40	W	1	0.7	
Ceresan 100	L	1/2	0.4	
Sanocide	W	1	0.4	
Ortho LM 42 (OR-839)	L	1/4	0.3	
Ortho LM 42 (OR-838)	L	1/4	0.2	
Emmi	W	1/2	0.1	
Panogen 42	L	1/5	0.1	
Ceresan 75	L	3/4	0.1	
Ceresan M	W	1/2	0.08	
Panogen 15	L	3/4	0.08	
Emmi	L	1/2	0.06	
Ceresan 200	L	1/4	0.04	

[a] L = Liquid; W = Wettable powder.

Table 2. Summary of results from seven regional seed-treatment tests for the control of soil-borne common bunt of winter wheat in the Pacific Northwest, 1958.

Treatment	Form[a]	Ounces per bushel	Mean percentage of bunt	Statistical Significance
Check - untreated	--	--	67.2	
Panogen 15	L	3/4	59.2	
Panogen 42	L	1/5	57.2	
Ceresan 200	L	1/4	45.2	
Ceresan 75	L	3/4	37.4	
Terraclor Liquid	L	2-1/4	22.0	
Terraclor	W	1	8.7	
Smut Go 40	W	1	7.7	
Anticarie	W	1	6.7	
No Bunt 80	W	1/2	5.4	
Monsanto Liquid PCNB	L	2-1/4	5.3	
Stauffer HCB-40	W	1	4.9	
Smut Go 80	W	1/2	4.2	
No Bunt 40	W	1	3.1	
Cal. Spray 80% HCB	W	1/2	2.9	
Sanocide	W	1	2.7	

[a]See footnote a, Table 1.

on winter or spring wheat, that is, all HCB formulations of at least 40 percent active ingredient, Panogen 15, and Ceresan M.

The results for the control of soil-borne common bunt are presented in Table 2. The high incidence of 67.2 percent bunt that developed in the untreated check rows indicates the severity of conditions for evaluating the performance of the different fungicides. All the formulations of HCB, the Monsanto Liquid PCNB, and the wettable powder formulation of Terraclor were highly effective in reducing the amount of infection by soil-borne spores. In contrast, the mercurial formulations (Panogen 15 and 42 and Ceresan 75 and 200) and Liquid Terraclor were relatively ineffective.

Table 3. Summary of results from seven regional seed-treatment tests for the simultaneous control of seed-borne and soil-borne common bunt of winter wheat in the Pacific Northwest, 1958.

Treatment	Form[a]	Ounces per bushel	Mean percentage of bunt	Statistical Significance
Check - untreated	--	--	81.8	
Ceresan 200	L	1/4	56.6	
Panogen 42	L	1/5	50.5	
Ceresan 75	L	3/4	47.2	
Panogen 15	L	3/4	46.7	
Terraclor Liquid	L	2-1/4	26.2	
Stauffer HCB-40	W	1	14.7	
Terraclor	W	1	11.0	
No Bunt 80	W	1/2	9.1	
Monsanto Liquid PCNB	L	2-1/4	8.5	
Smut Go 40	W	1	7.2	
Smut Go 80	W	1/2	6.5	
Sanocide	W	1	6.4	
Cal. Spray 80% HCB	W	1/2	5.7	
No Bunt 40	W	1	5.0	
Anticarie	W	1	4.4	

[a]See footnote a, Table 1.

Results from the tests for the simultaneous control of infection by seed-borne and soil-borne common bunt spores are summarized in Table 3. The incidence of bunt in the untreated check rows averaged 81.8 percent. Highly significant reduction in the amount of infection was obtained with Monsanto Liquid PCNB and all formulations of HCB except Stauffer HCB-40, whereas Terraclor, Terraclor Liquid, and Stauffer HCB-40 were somewhat less effective. The mercurials Panogen 15 and 42 and Ceresan 75 and 200 reduced infection only slightly. In these tests the percentages of bunt that developed from seed treated with mercury reflects effective control of the seed-borne phase and failure to control the soil-borne phase.

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PROTRACTED PERIOD OF VULNERABILITY OF WINTER WHEAT TO ATTACK BY TILLETIA CONTRAVERSA

L. J. Tyler

Abstract

Seedlings of Cornell 595 winter wheat that ranged from 20 to 52 days old when they were inoculated were vulnerable to attack by Tilletia contraversa, causal agent of dwarf bunt. Percentages of plants affected by dwarf bunt in five different age-groups were as follows: 20-day, 88.4; 31-day, 85.7; 38-day, 91.3; 45-day, 86.3; and 52-day, 26.6. Corresponding percentages of affected tillers for the same groups, respectively, were: 86.9, 89.3, 67.8, 62.5, and 41.1. These data show that destructive outbreaks of dwarf bunt can occur in winter wheat even though inoculation is delayed until plants are almost 2 months old.

The fact that coverings of straw maintained on wheat during winter months induce dwarf bunt, caused by Tilletia contraversa Kuehn (3, 4, 6, 7,), suggested that plants are susceptible to attack long after the initial stages of seedling development. In an effort to obtain information about this matter, Dewey (3) inoculated winter wheat plants that ranged from 2 to 21 days old. The inoculated plants were grown in a field nursery and wintered under straw cover. Dwarf bunt developed in plants of all age-groups; percentages of infection were highest in the 4-, 7-, 10-, and 21-day age-groups and lowest in plants of the 2-day age-group.

An experiment similar to Dewey's was performed to determine if winter wheat plants older than 3 weeks can be attacked by T. contraversa. This paper presents the results.

MATERIALS AND METHODS

Five staggered plantings of formaldehyde-treated Cornell 595 wheat seed were sown in disinfested soil in 4-inch pots, and the seeded pots were immediately set in disinfested soil to rim level in an outdoor nursery. Plantings were made in 100 pots on each of five dates: August 30, September 6, 13, and 20, and October 1. A slight variation of the method of seeding used by Dewey to facilitate delayed inoculation was used. Pots were filled to 1 1/2 inches below the top rim of each. A filter paper with a centered 1/2-inch hole was fitted on the firmed and leveled soil surface in each pot. Three seeds were placed in each pot on the soil area marked by the opening in the filter paper. The seeds were covered with about 1 1/4 inches of disinfested soil. Emerged seedlings were thinned to one per pot. All seedlings of each age group were transplanted and inoculated when seedlings of the October 1 planting reached the age of 20 days. Transplantation and inoculation were accomplished as follows. Each seedling with its ball of soil-embedded roots was removed from its pot; the soil above the filter paper was removed, exposing the shoot bases but leaving the roots undisturbed. It was essential that the roots be relatively undisturbed to avoid possible undesirable effects on the vulnerability of the seedlings to attack and to promote their survival during winter. The prepared seedlings were set in furrows in the field nursery. Topsoil mixed with dry chlamydospores of T. contraversa, on Sept. 25, and stored outdoors in a ground bin protected from rain (60 g of coarsely ground diseased whole wheat heads per bushel of soil) was packed around the transplants and in contact with the bases of shoots. The seedlings were transplanted and inoculated October 21, 1957. On December 3, 1957 the plants were covered with oat straw at the rate of 25 pounds per 100 square feet of ground surface; straw was removed April 3, 1958. Seedlings for transplanting were selected for uniformity within each age-group; the number selected and inoculated within each group ranged, therefore, from 40 to 60. Up to 30 of the remaining plants within each group were set in noninfested soil for use as check plants.

Representative seedlings were collected when the plants from each age group were transplanted and inoculated. These seedlings were photographed and afterward dissected to determine, in a general way, stages of plant development reached at the time they were inoculated. Stages of plant development are shown in Figure 1. At the time of inoculation, the lengths of seedlings measured from stem base to tip of the longest leaf, the number of main tillers, the number of smaller tillers mostly inclosed by sheaths, and the approximate number of tiller buds, respectively, for a representative seedling from each age-group were as follows:

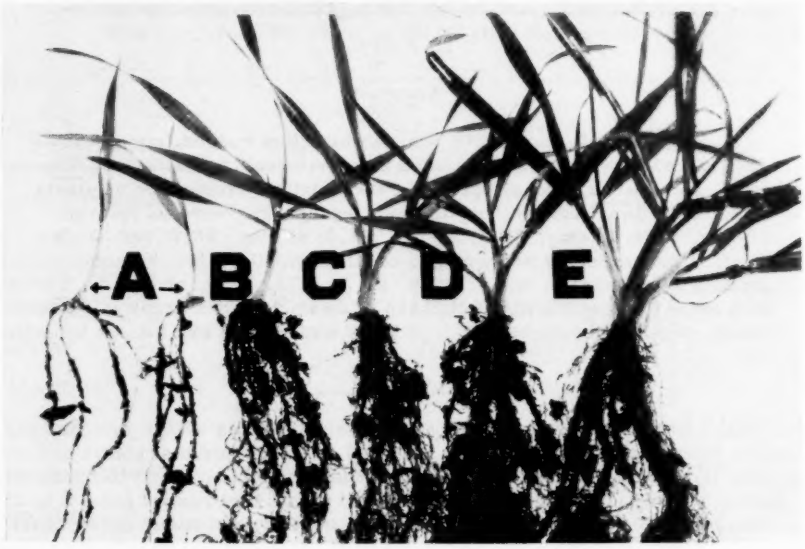

FIGURE 1. Seedlings of Cornell 595 winter wheat ranging in age from 20 to 52 days: A -- 20; B -- 31; C -- 38; D -- 45; E -- 52.

52-day-old seedling -- 7 inches, 7, 7, 17; 45-day-old seedling -- 5 inches, 4, 3, 12; 38-day-old seedling -- 4 inches, 3, 1, 8; 31-day-old seedling -- 3 1/2 inches, 1, 2, 3; 20-day-old seedling -- 2 1/2 inches, 1, 0, 3. Total numbers of plants and of tillers, and numbers of plants and tillers infected were recorded July 9-10, 1958.

RESULTS

Twenty-five percent of the inoculated plants in the 52-day age-group survived and matured, whereas approximately 50 percent of the inoculated plants in each of the other four groups did so (Table 1). Survival of noninoculated check plants was similar to their inoculated counterparts. Percentages of plants affected by dwarf bunt were very high (above 85 percent) for each age-group except the 52-day group which was moderately (26.6 percent) affected (Table 1). Noninoculated check plants were free of dwarf bunt.

On the average, plants of different ages tillered to about the same extent but the percentage of tillers affected by dwarf bunt tended to decrease as the age of plants at inoculation time became greater than 1 month (Table 1). The average number of infected tillers per infected plant varied considerably among the five age-groups, the numbers being highest in the 52-day group and lowest in the 45- and 38-day group. Data on total numbers of tillers produced by healthy plants were not separately recorded, hence the reputed ability of T. contraversa to induce excessive tillering in wheat is not clearly discernible.

DISCUSSION

Results herein show that winter wheat, growing under field conditions, is vulnerable to attack by T. contraversa even after having reached the age of almost 7 1/2 weeks at the time of inoculation. These results, considered together with Dewey's (3), reveal that destructive levels of dwarf bunt may be induced in winter wheat by inoculation of plants at any time from early stages of seed germination to almost 2 months after seeding. Similar results were obtained by Böning (1, 2) and Pichler (5) in Europe, although percentages of infection were much lower than those reported here. In addition, they found traces of dwarf bunt in field-grown plants inoculated during winter months; it must be assumed, however, that the observed traces of dwarf bunt did not result from natural soil-harbored inoculum.

Table 1. Number and percentage of winter wheat plants and tillers affected by dwarf bunt following inoculation of plants differing in age with Tilletia contraversa.

Plants					Tillers				
Age in days[a]	Number inoculated[b]	Number survived[c]	Affected by dwarf bunt number	Affected by dwarf bunt percent	Total number	Affected by dwarf bunt number	Affected by dwarf bunt percent	Average number per plant[d]	Average number infected per infected plant
52	60	15	4	26.6	326	134	41.1	21.7	33.6
45	40	22	19	86.3	446	279	62.5	20.3	14.6
38	40	23	21	91.3	451	306	67.8	19.5	14.4
31	50	21	18	85.7	497	444	89.3	23.6	24.6
20	50	26	23	88.4	597	519	86.9	22.9	22.5

a Age counted from date of seeding until date seedlings were transplanted and inoculated.
b Number of plants transplanted and inoculated.
c Number of inoculated plants that survived and matured. Comparable numbers of noninoculated check plants survived and were free of dwarf bunt.
d Average number per plant based on total tillers.

Worthy of note is the fact that percentages of plants and of tillers affected by dwarf bunt did not parallel each other. Percentage of plants infected did not drop until the age of plants at inoculation time reached 52 days. In contrast, percentage infected tillers began to diminish in plants inoculated at age 38 days and the trend continued through the 45- and 52-day groups. These results reflect the different stages of development shown by representative seedlings from the five age-groups (Fig. 1). Establishment of the pathogen in young seedlings, such as those in Fig. 1, A and B, could be expected to yield higher percentages of infected tillers than would establishment in seedlings like those in Fig. 1, C, D, and E. At inoculation time, tiller differentiation was scanty in plants of the two younger groups and invasion of the relatively undifferentiated basal meristem by the pathogen resulted in high incidences of tiller infection. As the seedlings grew, the basal meristem differentiated to form primary, secondary and even tertiary tillers. Inoculation of seedlings at times coinciding with these more advanced stages of development resulted in chance infection of some tillers and chances of tiller infection diminished with exposure of progressively older seedlings to inoculum. Percentage of infected plants, however, did not begin to diminish as soon as did percentage of infected tillers, because a single infected tiller produced by a plant places that plant in the category of infected. Thus, the percentage of plants in a given age-group infected by dwarf bunt can be high and tiller infection can be low. Eventually, of course, gross development of the seedling, such as shown in Fig. 1, E, provided barriers which the pathogen overcame with difficulty, and percentage of infected plants dropped suddenly as shown for those inoculated at the age of 52-days.

Finally, the straw cover method used for inducing dwarf bunt in winter wheat is, no doubt, dependent for its success upon the protracted period of vulnerability of plants to attack by T. contraversa. It is likely that winter coverings of straw on wheat plants simply help maintain an environment (affecting temperature and moisture in particular) favorable for the growth of the pathogen, including that necessary for ingress and establishment in the plant.

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VERTICILLIUM WILT RESISTANCE IN THE PROGENIES OF FRAGARIA CHILOENSIS FROM CHILE[1]

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Abstract

Seedlings of Fragaria chiloensis collected in Chile were tested for resistance to the Verticillium wilt disease caused by Verticillium albo-atrum Reinke & Berth. Resistant plants were found in three out of eight collections and tolerant plants in all but one. The suggestion is advanced that the resistance in certain cultivated varieties may have been introduced through F. chiloensis from North and South America and that by selfing certain cultivated varieties resistant lines may be isolated.

INTRODUCTION

Wilhelm (7) reported that seedlings of Fragaria chiloensis from Ambato, Ecuador are 100 percent susceptible to Verticillium wilt. He suggests that resistance to Verticillium wilt possibly was introduced into the garden strawberry from a North American form of F. chiloensis and bases this suggestion on the discovery of 12 resistant plants of F. chiloensis at Bodega Bay, California. However, there is variation in resistance among F. chiloensis from different locations on the North American continent. Newton and van Adrichem (5) have found that F. chiloensis from Newport, Oregon is susceptible although it carries 20 percent resistant plants in its selfed seedlings. In view of results obtained by Wilhelm (7) and by Newton and van Adrichem (5), a study was undertaken to determine if Chilean forms of F. chiloensis carry resistance to Verticillium wilt.

MATERIALS AND METHOD

Seeds of F. chiloensis were collected by Dr. G. M. Darrow (3) at the following locations: U. S. Plant Introduction No. 235880, White Chilean variety from market, grown at Cobquecura; No. 236006, pistillate, in pasture, Fundo El Salto, Cunco; No. 236104, hermaphrodite, White Chilean variety from Ernesto Furro, Puren; No. 236105, wild from market, Ancud, Chiloe; No. 236994, wild from hillside 5 k. from Coyhaique; No. 237002, Red Chilean variety from Fundo Las Mercedes, 12 k. north of Santiago; No. 237021, 20 k. from Coyhaique toward C. Alta from hill between Bull and Hidden Lakes, many hermaphrodite in area. No. 237619, from John Bucher, Castri, Chile, collected south end of Chiloe.

The seeds were sown in the greenhouse in August 1957 and germinated after 4 weeks. White Chilean No. 235880 and No. 236104 showed a slower and lower percentage germination than did the collections of Red Chilean.

A number of seedlings were inoculated during January 1958 with a virulent strain of Verticillium albo-atrum Reinke & Berth., a strain highly pathogenic to tomatoes as well as to strawberries. The seedlings were removed from the flats and washed under running water. During this process some roots of all plants were broken or otherwise injured, and in this way a condition more favorable for infection by the pathogen was created. Roots and crowns were then immersed in a spore suspension for 24 hours. The spore suspension was prepared by macerating three 30-day-old cultures of Verticilllium grown on lima bean agar in 300 ml of water. After inoculation the seedlings were planted in flats filled with steam-sterilized soil, and a further portion of the inoculum was poured around each plant. The plants were placed in a growth chamber at a temperature of between 50° and 60° F. A light period of 18 hours was provided by fluorescent lights. The soil was kept relatively wet to provide optimum conditions for infection (4).

Seedlings that showed symptoms of Verticillium wilt after a growth period of 8 weeks were discarded. These symptoms consisted of a blackening and dying of the petioles, often followed

[1] Contribution No. 1727 from the Botany and Plant Pathology Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario.

by the death of the whole plant. The apparently normal seedlings were then lifted and reinoculated as before and replanted in the same flats. After an additional 8-week growth period, seedlings that showed symptoms of Verticillium wilt were discarded. This procedure was repeated for a third time. It was noted that symptoms developing after this third inoculation were usually mild.

Seedlings that showed symptoms following the first two inoculations were classed as susceptible. Those that showed symptoms after the third inoculation were classed as tolerant. Those that remained normal in appearance throughout the experiment were classed as resistant.

Young runner plants of the wilt-susceptible variety Northwest were propagated in a root-rot-free condition by the method described by van Adrichem and Bosher (6). These plants were inoculated with Verticillium albo-atrum at the same time that the seedlings of Chilean origin were inoculated. The purpose was to provide a basis for comparison between the wilt-susceptible variety and the unknown seedlings.

RESULTS

Table 1. Resistance to Verticillium wilt of the progenies of some plants of Fragaria chiloensis from Chile.

Seedlings U. S. P.I. No.	Number of plants tested	Number of plants classed as		
		Susceptible	Tolerant	Resistant
235880	25	20	5	--
236006	50	33	12	5
236104	44	40	4	--
236105	100	82	7	11
236994	100	79	19	2
237002	100	64	36	--
237021	50	43	7	--
237619	100	100	--	--
Northwest asexually	10	10		

The data in Table 1 show that seedlings of Chilean F. chiloensis from some locations carry resistance to Verticillium wilt. The notable feature is the variation from complete susceptibility of No. 237619 to the 11 percent of resistant plants obtained from No. 236105. The lowest percentage of susceptible plants was produced by No. 237002 in which 36 percent proved to be tolerant yet none could be classed as resistant. The tolerance of all numbers except No. 237619 is noteworthy and indicates that some degree of resistance is present.

Northwest showed severe symptoms of infection after the first inoculation.

The observation was made that, under the conditions of the test, powdery mildew (Sphaerotheca macularis) was much more severe on the Chilean forms than on the North American forms of F. chiloensis that were grown at the same time under identical conditions. Seedlings of the group No. 236105 were not as severely attacked by powdery mildew as were the other numbers, it being further noted that No. 236105 seedlings had a rather glossy foliage whereas the foliage of others was relatively dull.

DISCUSSION

From these results, it appears possible that resistance to Verticillium wilt in the cultivated strawberry may have been introduced from a Chilean F. chiloensis as well as from the North American forms suggested by Wilhelm (7). Etter used Chilean F. chiloensis in his breeding work (1). His seedlings have been widely used in the North American strawberry breeding program (2).

From this study and the results reported by Wilhelm (7) and Newton and van Adrichem (5), it would seem possible to find seedlings resistant or tolerant to Verticillium wilt in the selfed populations of some of the cultivated strawberry varieties.

ACKNOWLEDGMENT

The authors are deeply indebted to Dr. George M. Darrow, United States Department of Agriculture, Beltsville, Maryland, for generously providing the seeds of F. chiloensis used in these studies.

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FORECASTING BULL'S-EYE ROTS IN NORTHWEST-GROWN APPLES IN STORAGE

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Summary

Apple rots of the bull's-eye type, incited primarily by Neofabraea perennans Kienh. and Phialophora malorum (Kidd. & Beaum.) McColloch, occur relatively late in the storage life of the fruit and are responsible for serious losses to the fruit industry. Storage of sample lots of apples at 60° to 70° F shortens the incubation period for the disease and permits the forecasting of the disease in the parent lot in cold storage. The time spread in the appearance of symptoms is great enough to permit marketing the parent lot before the disease would normally occur under cold storage conditions. Preliminary data indicate that other disorders may also be forecast in the same manner.

Apple rots of the bull's-eye type frequently cause serious losses of apples in cold storage (3, 6). These rots may be caused by several organisms (2), but the rots incited by two wood-cankering organisms, Neofabraea perennans Kienh. and Phialophora malorum (Kidd & Beaum.) McColloch, are particularly troublesome in the Pacific Northwest (3, 4). Fungicide sprays in the orchard have materially reduced infection by N. perennans (3), and personal observations in the Wenatchee area of Washington indicate that this may also be true for P. malorum. Infection can still occur, however, if there is rainfall just before harvest, when the presence of props in the orchard limits the use of spray equipment. Fruit from orchards with histories of these diseases is generally marketed early in the storage season, at which time unfavorable prices may prevail. Losses of income to the grower may also be sustained when the trees in an orchard with no history of these diseases become infected following severe winter injury. The presence of even a small percentage of these rots results in severely discounted prices at a terminal market. The possibility of late-season infection in sprayed orchards and the reluctance of some growers to follow the necessary spray program pointed out the need for developing methods that would enable the warehousemen to forecast the occurrence of these diseases in grower-lots of fruit in cold storage. Following the lead of Harvey (1), who developed methods for forecasting decays in grapes, experiments with apples were initiated in 1956.

MATERIALS AND METHODS

Twelve boxes of loose Winesap apples from each of three orchards with histories of bull's-eye rots were obtained from a cooperating warehouse. Composite samples were prepared within each grower-lot. Three boxes of fruit per grower-lot were stored loose at 31°, 50°, 65°, and 80° F, respectively. Polyethylene bags were slipped over the boxes of fruit stored at 80° to prevent desiccation. The fruit was examined at 14-day intervals, and the incubation period for the disease was determined at each temperature.

In 1957 the 50° temperature was eliminated, since it could not be maintained conveniently at most warehouses. Packed fruit, which constitutes a more representative sample of the grower-lot, was used instead of loose fruit. Polyethylene bags, the use of which has been shown to increase the number of lesions in infected fruit (5), were used to cover the boxes of fruit at both 65° and 80°. The number of grower-lots of fruit assayed in the laboratory was increased to five. Incubation periods for the disease were again determined at each temperature. Observations were also made on 75 lots of fruit that were being assayed on a commercial basis at a cooperating warehouse.

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EXPERIMENTAL RESULTS

The incubation period for the disease in each grower-lot was shortened as temperature increased (Table 1). In 1956 the average incubation period for the disease at 80° was 128 days shorter than that at 31°. At 65° and 50° the incubation periods were shortened by 100 days and 88 days, respectively. In 1957 the incubation period for the disease was shorter at all temperatures. A period of abnormally hot weather in August of 1957 undoubtedly contributed to a state of advanced maturity at harvest time. The time spread between the appearance of disease symptoms at 80° and at 65° as compared with 31° was 76 days and 63 days, respectively. There was a close correlation (r = 0.96) between the percentages of decayed apples forecast at 65° F and the percentages decayed in cold storage (Table 2).

Table 1. Incubation period of bull's-eye rot of apple at various temperatures.

Year and lot number	Temperature (degrees F)			
	80°	65°	50°	31°
	Number of days			
1956 - 1	40	81	104	179
1956 - 2	40	56	62	136
1956 - 3	28	56	63	179
1957 - 1	29	43		120
1957 - 2	--[a]	43		120
1957 - 3	35	49		109
1957 - 4	35	49		101
1957 - 5	35	49		99

[a] Bull's-eye counts could not be made owing to the large amount of breakdown.

Table 2. Percentage of apples infected with bull's-eye rot after storage at 31° and at 65° F[a].

Storage	Lot number					
	1	2	3	4	5	6
After 230 days at 31°	1.2	9.5	17.4	41.6	35.5	35.6
After 80 days at 65°	1.1	10.9	17.0	39.0	43.9	45.1

[a] Correlation coefficient = 0.96

In both years disease symptoms developed early enough in all of the samples at the higher temperatures to permit the marketing of the parent lot before disease symptoms would have appeared in cold storage. Data were taken on the incidence of other storage disorders in 1957 with the hope that they might also be forecasted by the same method. The ultimate goal of these studies is to be able to predict the approximate date for the appearance of the disease in cold storage and to determine a safe marketing period which would enable the shippers to take advantage of more favorable markets. For the present, however, the ability to determine in advance which lots of fruit will develop these diseases will result in a considerable saving to the industry and will assure the delivery of high-quality fruit at the consumer level.

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CONTROL OF FIREBLIGHT OF PEAR WITH AGRI-MYCIN FORMULATIONS

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Abstract

Agri-mycin 100 and Agri-mycin 500 are capable of giving reasonable protection against fireblight (Erwinia amylovora) if applied every 4 or 5 days during the critical period, beginning with 10 percent bloom, whether applied as dust or spray. Spray treatments, if applied the same number of times as dust forms, seem to give a better and more lasting effect.

The fireblight disease of pear, caused by Erwinia amylovora, is successfully controlled by either wettable or dust formulations containing streptomycin alone or with the addition of a second antibiotic (oxytetracycline), as in Agri-mycin 100. An improved type of Agri-mycin in which a copper additive is claimed to provide a synergistic effect is being offered to enhance the bactericidal efficacy as compared with other forms of agricultural streptomycin. The phenomenon of seeming synergistic action of copper in combination with streptomycin was reported in 1955 by Cox (1) in the control of bacterial blight of celery. Zaumeyer (3) noted considerable improvement in the control of downy mildew of lima beans when he used Agri-mycin 500, which contains copper, over the series where Agri-mycin 100 was used. Miller (2), in his recent report on the control of walnut blight in Oregon, stated that Agri-mycin 500 showed better control of the disease than did Agri-mycin 100 under severe epidemic conditions.

To check on the performance of Agri-mycin formulations with and without copper, a plot consisting of 1202 fruit-bearing pear trees was set up in a section of the State where fireblight is known to occur in epidemic form if proper control measures are not taken. Agri-mycin 100 (streptomycin, 15 percent; oxytetracycline, 1.5 percent) and Agri-mycin 500 (streptomycin, 1.76 percent; oxytetracycline, 0.18 percent and metallic copper, 42.4 percent, 35 percent, and 10 percent)[2] were used as both dust and spray formulations. All chemicals were applied to the trees by ground equipment. The first application, on March 15, was made at the time when trees showed about 10 percent bloom. Other applications were made March 19, 22, 24, 28; April 4, 12, 18, 25; and May 3. Dusts were formulated to contain 1000 and 2000 ppm of streptomycin, while wettable formulations were adjusted to contain 60 ppm. Dusts were used at the rate of 30 and 50 pounds to the acre, and sprays at 700 gallons to the acre.

It should be mentioned that in 1958 the blossoming of pear trees was extremely erratic and many new blossoms developed after the tenth application of the antibiotic formulations, when the supply of the experimental materials was completely exhausted. During this period, that is, from May 23 to June 19, the average maximum temperature of air was 80.2° F, the average minimum temperature 56°, and the average relative humidity 50 percent. With a big blight potential existing in the orchard (see Table 1) it was necessary to provide some protection to the experimental plots (except the check) after the supply of the antibiotic was exhausted. This was done by making two airplane applications, on May 23 and June 9, of copper-lime (10/90) dust at the rate of 25 pounds to the acre.

Results of the tests are presented in Table 1. The table was made in the following way. The average number of cuts per tree to remove blight infections was computed by taking the total number of cuts made on each of the first three cutting operations and dividing this by the number of trees in a given plot. In this way it was possible to ascertain the effect of the antibiotic formulations on fireblight under conditions of the reasonable time given for the expression of the disease as it would have been under the conditions of adequate supply of the test materials and regular schedule of application. It is felt that this procedure gives a realistic appraisal of the results of the tests. Table 1 indicates the average number of cuts made per tree as computed for the operations that started on May 9, (that is, 3 days after the last application of the treatments) and represents infections developed from the beginning of flowering, continuing through May 27 (that is, 24 days after the last treatment), and ending with the oper-

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[2]The writer expresses his gratitude to Chas. Pfizer & Co., Inc., Brooklyn, New York, for providing quantities of all formulations of Agri-mycin used in the present work.

Table 1. Average number of cuts of fireblight per tree in experimental plots which received Agri-mycin 100 and Agri-mycin 500 formulations. Summer, 1958.

Dust formulations	Average number of cuts per tree on			Spray formulations	Average number of cuts per tree on		
	May 6	May 27	June 19		May 6	May 27	June 19
Agri-mycin 100 1000 ppm 50 pounds/acre 165 trees	.060	.939	6.872	Agri-mycin 100W 60 ppm 70 trees	.029	.285	.128
Agri-mycin 500 [a] 1000 ppm 50 pounds/acre 420 trees	.098	.040	6.380	Agri-mycin 500W (42 percent copper) 60 ppm 7 trees	.145	.145	1.450
Agri-mycin 500 2000 ppm 50 pounds/acre 165 trees	.067	.697	5.156	Agri-mycin 500W (35 percent copper) 60 ppm 7 trees	0	0	8.857
Agri-mycin 500 2000 ppm 30 pounds/acre 165 trees	.085	.951	2.151	Agri-mycin 500W (10 percent copper) 60 ppm 7 trees	0	.145	9.285
Check: Untreated 31 trees	.064	2.030	14.00				

[a]Dust prepared in 1957.

ations of June 19, which represented a period of 36 [46] days without antibiotic protection and only two light applications of copper-lime (10/90) dust.

The following conclusions may be drawn: 1) All dust formulations of Agri-mycin are capable of giving good protection against fireblight, whether used at 1000 ppm or 2000 ppm. Even a year-old formulation of Agri-mycin 500 was quite effective in controlling the blight. 2) Decreasing poundage of the dust to 30 pounds per acre sharply increased the amount of fireblight. 3) Wettable applications of Agri-mycin 100 and Agri-mycin 500 (total of 10 applications) gave excellent results on the basis of 70 experimental trees for Agri-mycin 100 and 7 trees for each of Agri-mycin 500 formulations.

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DISINFECTANTS AND TOOL DISINFECTION FOR PREVENTION OF SPREAD OF BACTERIAL WILT OF BANANAS

I. W. Buddenhagen and L. Sequeira

Abstract

The agent of bacterial wilt of bananas, Pseudomonas solanacearum E. F. Smith, is readily transmitted from plant to plant on the knives used in pruning operations. Laboratory tests were carried out with 18 organic and inorganic chemicals as possible materials for tool disinfection. Due either to the instability of most of these chemicals in the presence of banana sap, or to their toxicity, only formaldehyde was considered satisfactory for field use. A cursory disinfecting wipe with formaldehyde was not sufficient to prevent transmission of the bacterium, but complete disinfection was possible when the knives were completely immersed in a 10 percent solution of formaldehyde for 10 seconds.

INTRODUCTION

Bacterial wilt, or Moko disease, is one of the three most destructive diseases of bananas in Central America. The causal agent, Pseudomonas solanacearum E. F. Smith, is readily transmitted from plant to plant on the knives (machetes) used in the monthly pruning of the banana suckers (1). It is believed that, with the exception of seed transmission, the pruning operation is the principal means of the rapid spread of this highly infectious organism.

Although 5 percent formaldehyde has been recommended for some time (2) for use as a disinfectant, a simple means of rapid and effective knife disinfection has been lacking. Investigations reported here concern laboratory testing of various disinfectants and practical field evaluation of disinfection methods with formaldehyde.

METHODS

Disinfectants were tested in the laboratory against an isolate of Pseudomonas solanacearum from banana by introducing 0.1 ml of a 48-60 hour nutrient broth bacterial culture into 10 ml of the chemical appropriately diluted in distilled water. The tube was then agitated and one loop of the solution was transferred to nutrient broth after 1/2, 1 and 5 minutes. The nutrient broth tubes were checked for turbidity after 48 and 60 hours. The more effective chemicals were then tested in the presence of 10 percent (w/w) sterile soil or 10 percent (v/v) sterile banana sap. Banana sap was collected aseptically from severed pseudostems and mixed with the diluted chemical solution.

In field tests designed to determine the effectiveness of various methods of machete disinfection, the machete was first contaminated by drawing the blade through a diseased sucker so that at least 5 inches were covered with the bacteria-containing sap. Three different methods were then used to bring the machete into contact with formaldehyde (Figure 1): 1) The "scabbard immersion" method consisted of immersing a machete in a metal scabbard containing 2 liters of the disinfectant. 2) The "sponge-pail" method consisted of wiping the machete twice with a sponge that had been soaked in a pail of formaldehyde solution. 3) The "gancho" method consisted of wiping the machete across a sponge attached to a hollow aluminum tube containing formaldehyde. The aluminum tube was provided with small holes through which the formaldehyde was absorbed by the sponge. Each side of the machete was drawn across the gancho sponge twice. After disinfecting for a definite time interval one healthy sucker was cut. The machete was then cleaned of any remaining disinfectant, recontaminated, disinfected and used again, the cycle being repeated until 50 suckers per treatment were cut.

Disease readings were taken after 3 weeks by cutting the suckers and checking for the discolored vascular strands characteristic of Moko disease. Many of the suckers were stunted and exhibited blackening of the outer leaf sheaths (Figure 2). The Gros Michel variety was used in all tests.

The active ingredients of compounds tested are as follows: Ceresan-M (ethyl mercury p-toluene sulfonanilide 7.7 percent), Hyamine 3500 (n-alkyl dimethyl benzylammonium chloride 50 percent), Experimental quaternary R-2731 (Rohm & Haas, 50 percent), Lo-Bax-W (calcium

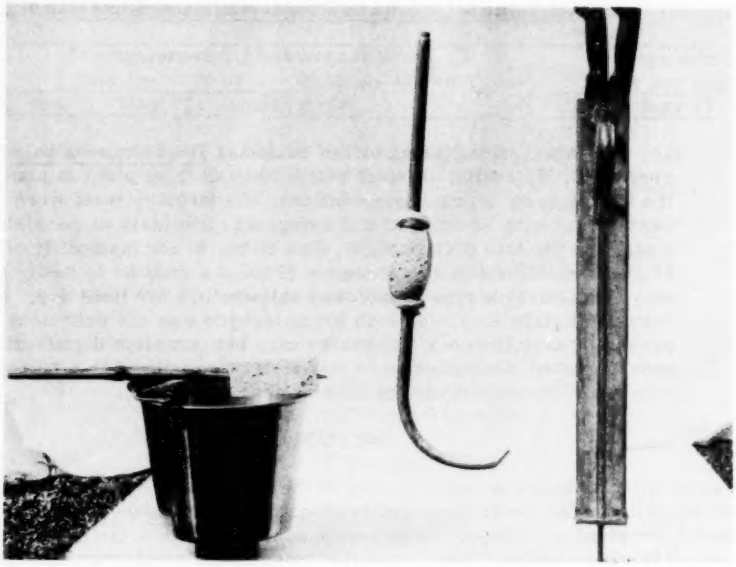

FIGURE 1. Tools used for knife disinfection: sponge-pail, gancho, and scabbard.

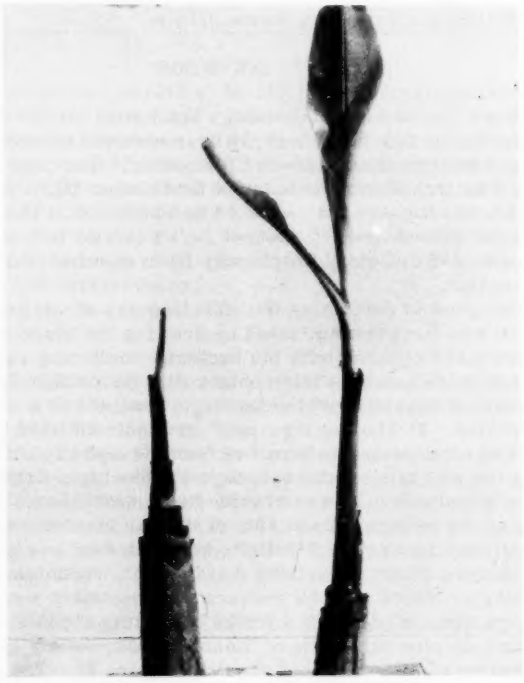

FIGURE 2. Regrowth of banana suckers 3 weeks after cutting with a knife contaminated with P. solanacearum (left), and a disinfected knife (right).

hypochlorite 21 percent, Olin Mathieson), Hyamine 2389 (alkyl tolyl methyl trimethyl ammonium chlorides 50 percent), Hyamine 2744 (octyl phenoxy ethoxy ethyl dimethyl p-chlorobenzyl ammonium chloride 97 percent), Hyamine 1622 (p-diisobutyl phenoxy ethoxy ethyl dimethyl benzyl ammonium chloride monohydrate 98.8 percent), Cyprex (dodecylguanidine acetate 70 percent), Semesan (hydroxy mercuri chlorophenol 28.6 percent), Lysol (50 percent crude cresols), Omadine disulfide (dithiopyridine dioxide 50 percent, Olin Mathieson), Omadine zinc (zinc salt of pyridine thione 50 percent), Dithane D-14 (disodium ethylene bisdithiocarbamate 19 percent), Vancide 51 (sodium dimethyl dithiocarbamate 27.6 percent; sodium salt of 2-mercaptobenzothiazole 2.4 percent). All concentrations given in the tables are based on active ingredient.

RESULTS

Laboratory

Eighteen chemicals were tested for bactericidal action against Pseudomonas solanacearum, and are ranked in order of effectiveness in Table 1. Five of the chemicals tested were completely bactericidal in 30 seconds at concentrations as low as 100 ppm active ingredient. One of these was an organic mercury compound (Ceresan M), one an antibiotic (Aureomycin), two were quaternary ammonium compounds (Hyamine 3500, and Experimental R-2731), and one contained calcium hypochlorite (Lo-Bax-W). Formaldehyde, the chemical in current use as a machete disinfectant, was bactericidal only at a concentration of 10,000 ppm or higher.

Table 1. Bactericidal effectiveness of different chemicals against Pseudomonas solanacearum.

Chemical	Parts per million (active ingredient)																	
	100			500			1000			5000			10,000			50,000		
	Minutes[a]																	
	1/2	1	5	1/2	1	5	1/2	1	5	1/2	1	5	1/2	1	5	1/2	1	5
Ceresan M	-	-	-[a]															
Aureomycin	-	-	-															
Hyamine 3500	-	-	-															
Experimental Quaternary	-	-	-	-	-	-												
Lo-Bax-W	-	-	-	-	-	-												
Hyamine 2389	+	+	-	-	-	-												
Hyamine 2744	+	+	-	-	-	-												
Cyprex	+	+	+	-	-	-												
Hyamine 1622	+	+	-	+	-	-												
$KMNO_4$	+	+	+	+	+	-				-	-	-						
Semesan	+	+	+				+	-	-									
Formaldehyde	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-			
Lysol	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-			
Phenol	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-			
Omadine disulfide[b]	+	+	+				+	+	+									
Omadine zinc[b]	+	+	+				+	+	+									
Dithane D-14													+	+	+	-	-	-
Vancide 51							+	+	+				+	+	+	+	-	-

[a]Growth (+) or no growth (-) after 48 hours in nutrient broth, following exposure to chemical for 30 seconds, 1 minute and 5 minutes.
[b]Ranking uncertain.

Cyprex, Vancide 51, and three of the more effective chemicals were compared with formaldehyde for bactericidal action in the presence of soil or banana sap (Table 2). The effectiveness of each of these chemicals, with the exception of formaldehyde, was markedly reduced by banana sap. Soil reduced the effectiveness of all except formaldehyde and Lo-Bax-W.

Table 2. Effect of soil or banana sap on bactericidal action of various chemicals.

Chemical (ppm)	Alone[b] Minutes 1/2	1	5	Plus sap[a] Minutes 1/2	1	5	Plus soil[a] Minutes 1/2	1	5
Hyamine 3500 1000	-	-	-	+	+	+	+	+	+
2000	-	-	-	-	-	-	-	-	-
Exp. Quat. R-2731									
200	-	-	-	+	+	+	+	+	+
500	-	-	-	+	+	+	+	+	+
Lo-Bax-W 200	-	-	-	+	+	+	-	-	-
500	-	-	-	+	+	+	-	-	-
Cyprex 100	+	+	-	+	+	+	+	+	+
500	-	-	-	+	+	+	+	+	+
Vancide 51 50,000	+	-	-	+	+	+	+	+	+
Formaldehyde 5,000	+	+	-	+	+	-	+	+	-
10,000	-	-	-	-	-	-	-	-	-

[a]Chemical solution contained 10 percent by volume of sterile banana sap, or 10 percent by weight of sterile soil.

[b]Growth (+) or no growth (-) after 48 hours in nutrient broth, following exposure to chemical for 30 seconds, 1 minute and 5 minutes.

Field Testing

In the first laboratory screening many chemicals were found to be more effective than formaldehyde at equal concentrations. However the effectiveness of several of these chemicals was reduced in the presence of banana sap. Other candidate chemicals were considered too toxic to man or too expensive for field use. In addition to formaldehyde, Hyamine 3500 was considered to merit a field test (Table 3).

Table 3. Disease incidence following machete disinfection by immersion in Hyamine 3500.

Chemical	Concentration Active ingredient (ppm)	Disease incidence (percent) Immersed 10 seconds	Immersed 30 seconds
Hyamine 3500	1000	40	26
Hyamine 3500	2000	24	0
Hyamine 3500	5000	14	0
Control (no disinfectant)		80	

Machete immersion in 2000 ppm of Hyamine 3500 for 30 seconds eliminated disease transmission; but immersion for only 10 seconds was not completely effective even at 5000 ppm. For this reason, formaldehyde was considered the most promising candidate disinfectant for use in banana pruning and a detailed study of tool-disinfection procedures with this chemical was carried out.

Disinfection Methods with Formaldehyde

Examination of the gancho, a tool that has been in current use, showed that the sponge was soon occluded by banana sap, and the flow of formaldehyde to the sponge was often erratic. Other more simple tools, such as a bamboo section containing formaldehyde with a piece of burlap protruding through a slit, had similar drawbacks. Experiments showed that rapid wiping of a machete over an only partially wet sponge was not sufficient to disinfect the blade.

A comparison was made for efficiency between the gancho and scabbard-immersion methods at two formaldehyde concentrations (Table 4).

Table 4. Disease incidence following machete disinfection by two methods at two formaldehyde concentrations.

Method[a]	Formaldehyde concentration (percent)	Disease incidence (percent)
Scabbard immersion	5	0
Gancho	5	0
Scabbard immersion	1.3	36
Gancho	1.3	44
Control (no disinfection)		95

[a]Time from complete coverage of machete by solution to cutting test sucker was 30 seconds.

It is interesting that although a 1 percent solution was effective in killing bacteria in laboratory tests, a 1.3 percent solution allowed up to 44 percent disease transmission in the field test.

Although no transmission occurred with the gancho method at a concentration of 5 percent, the gancho sponge was becoming occluded with banana sap by the end of the experiment and it was difficult to obtain good coverage of the machete blade.

Formaldehyde was then tested at two concentrations and various time intervals by the scabbard method and by the sponge-pail method (Table 5).

Table 5. The effect of disinfection time and formaldehyde concentration on machete disinfection by two methods.

Method	Formaldehyde concentration (percent)	Time in seconds[a]	Disease incidence (percent)
Scabbard	5	10	2
Scabbard	5	20	2
Scabbard	5	30	0
Sponge-pail	5	10	4
Sponge-pail	5	20	4
Sponge-pail	5	30	0
Scabbard	10	10	0
Sponge-pail	10	10	0
Control (no disinfectant)			95

[a]Time from complete coverage of machete by solution to cutting test sucker.

Thirty seconds were required to insure complete disinfection at a concentration of 5 percent. Only 10 seconds were required for complete disinfection at a concentration of 10 percent.

An experiment was then carried out to determine disease incidence after a laborer had pruned as rapidly as possible a row of banana plants bearing a large number of suckers. In this case the machete was contaminated and rapidly disinfected between each plant. The sponge-pail system of disinfecting was used with 5 percent formaldehyde. Time interval between plants averaged only 7 seconds; disinfecting time was somewhat less. Disease incidence following pruning of 50 suckers under these conditions was 36 percent.

DISCUSSION AND CONCLUSIONS

The bacterium that causes bacterial wilt of bananas may be inadvertently transmitted from a diseased, but relatively symptomless, plant to other plants on machetes used in the pruning operation. The bacterium is so readily transmitted by machetes that a cursory disinfecting wipe is insufficient to prevent transmission. Normal pruning speed often leaves insufficient time for the complete disinfection of the machete between banana plants. It was found that complete disinfection was possible if the machete were immersed in 10 percent formaldehyde for 10 seconds. Although wiping the machete thoroughly with a sponge that had been immersed in a pail of formaldehyde was effective, it is not easy for the laborer to carry out this operation consistently. The simplest disinfection method appears to be machete immersion in a metal scabbard of sufficient size to accommodate two machetes. The alternate use of two machetes greatly reduces the chances of bacterial transmission and, provided this procedure lengthens disinfecting time to 30 seconds, it would permit the use of 5 percent formaldehyde.

Although several of the many chemicals tested in the laboratory were much more effective than formaldehyde against Pseudomonas solanacearum, most of them were readily inactivated by banana sap or were considered to be toxic, unstable, or expensive. A candidate bactericide should be less expensive than formaldehyde[1] at a concentration sufficient to kill in 30 seconds in the presence of banana sap. It should also be almost as effective in 10 seconds as in 30 seconds, of low toxicity to man, and stable under tropical conditions. Although Hyamine 3500 at a concentration of 1 percent would be somewhat less expensive than formaldehyde, its low effectiveness at 10 seconds makes it less trustworthy.

A satisfactory method of pruning which consists of pulling off the banana suckers by hand is a practice that has recently been adopted on some banana farms. This eliminates the need for machete disinfection during the pruning cycle. However, machete disinfection is still essential on many farms where machete pruning continues and in quarterly general farm cleaning and especially during the large amount of clean-up work needed following windstorms.

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CIA. BANANERA DE COSTA RICA, COTO RESEARCH STATION, GOLFITO, COSTA RICA
(A subsidiary of United Fruit Company)

[1] Five percent formaldehyde, diluted from 37 percent commercial formalin, costs approximately 12 cents, United States currency, per gallon in Costa Rica.

EVALUATION OF 160 VARIETIES OF GLADIOLUS FOR RESISTANCE TO FUSARIUM YELLOWS, 1958

John G. Palmer and R. L. Pryor[1]

Since gladiolus varieties are field grown, corms are exposed to soil-borne diseases, and uninfected stock is not available commercially. The selection of resistant varieties was begun by inoculating gladiolus corms with a composite inoculum of six isolates of Fusarium oxysporum Schlecht. f. gladioli (Massey) Snyder & Hansen. Two of the isolates (301 and 304) had been used by McClellan and Pryor[2], two (A and B) were obtained from R. O. Magie, Gulf Coast Experiment Station, Bradenton, Florida; and two (0 and V) were isolated from corms grown in the field at Beltsville in 1957. Twenty-four corms of each of 119 varieties and corms of 42 varieties with less than 24 but at least 15 corms were randomly divided into three groups with at least five corms in each. On April 8 and 9, 1958 corms in two of the groups were inoculated by rotating each over a hardware-cloth grid in sand saturated with a spore and mycelial suspension composed of equal amounts of the Fusarium isolates. For the third group of corms tap water replaced the inoculum. The sequence of varieties was randomized, and the corms in each treatment were planted in three different benches containing a substrate of steam-sterilized hadite that had been soaked in water for 24 hours. Each bench was divided into six sections, each being isolated from the others, subirrigated independently, and holding at most the corms of 39 varieties. One week after planting time each bench was subirrigated with tap water, and on the tenth day and twice weekly thereafter each was subirrigated with a balanced nutrient solution. After 9 weeks the night temperature was reduced from 80° to 70°F.

The numbers of germinated shoots and of shoots showing symptoms were recorded twice weekly over a period of 14 weeks. Summaries of recorded data in Table 1 and Table 2 indicate that immunity to yellows was not found but that variable degrees of resistance to isolates of the pathogen existed among the varieties of gladiolus. In 51 of the varieties there was a time lapse of 3 or more weeks between the recorded date for 100 percent symptomology in the inoculated groups and that for 100 percent in the control group of the same variety. In 42 varieties symptoms never occurred on 100 percent of the control shoots. In only 18 varieties did the control group become 100 percent symptomatic before, at the same time, or within 1 week after the inoculated groups. These facts were interpreted as indicating a successful inoculation resulting from infection by one or more of the isolates in the composite inoculum.

Some shoots from inoculated corms of two varieties, Ladykiller and Alice Adams, became symptomatic. Two varieties (Carnival and Loveliness) required 14 weeks before yellowing of 100 percent of shoots occurred. Eleven varieties (Apricot Glory, Dusk, Easter Parade, Exemplar, New York, Purple Burma, Skyrocket, Snow Princess, Sweet Sixteen, Wild Rose, and Yellow Bird) required 12 weeks for all shoots to show symptoms. One inoculated group of Golden Ophelia (Table 1) and White Gold (Tables 1 and 2) required 14 weeks and one required 12 weeks for all shoots to become symptomatic. These 19 groups representing 17 varieties were considered to have potentially useful resistance and will be evaluated further. The 143 varieties in which 100 percent of the shoots from inoculated corms became yellowed in 10 weeks or less were considered susceptible. Approximately 10 varieties in whose control groups the shoots never became completely symptomatic show promise for use in a spectrum designed to evaluate pathogenicity of isolates being used and to select replacement isolates of the pathogen having similar host ranges as they may be needed. Nine varieties (Dauntless, Debutante, Friendship, Golden Ophelia, King Click, Lady Jane, Parade, Patrician, and White Gold) were replicated in the experiment, and there was a lapse of 2 weeks or less between yellowing of 100 percent of shoots of the two groups of inoculated corms of all the varieties except Dauntless. For these varieties the responses of the control replications were also similar except for Dauntless, with six of the varieties and one replication of Dauntless relatively free of natural inoculation. These results supported the validity of the inoculation procedure and indicated that conditions were relatively similar in the various locations.

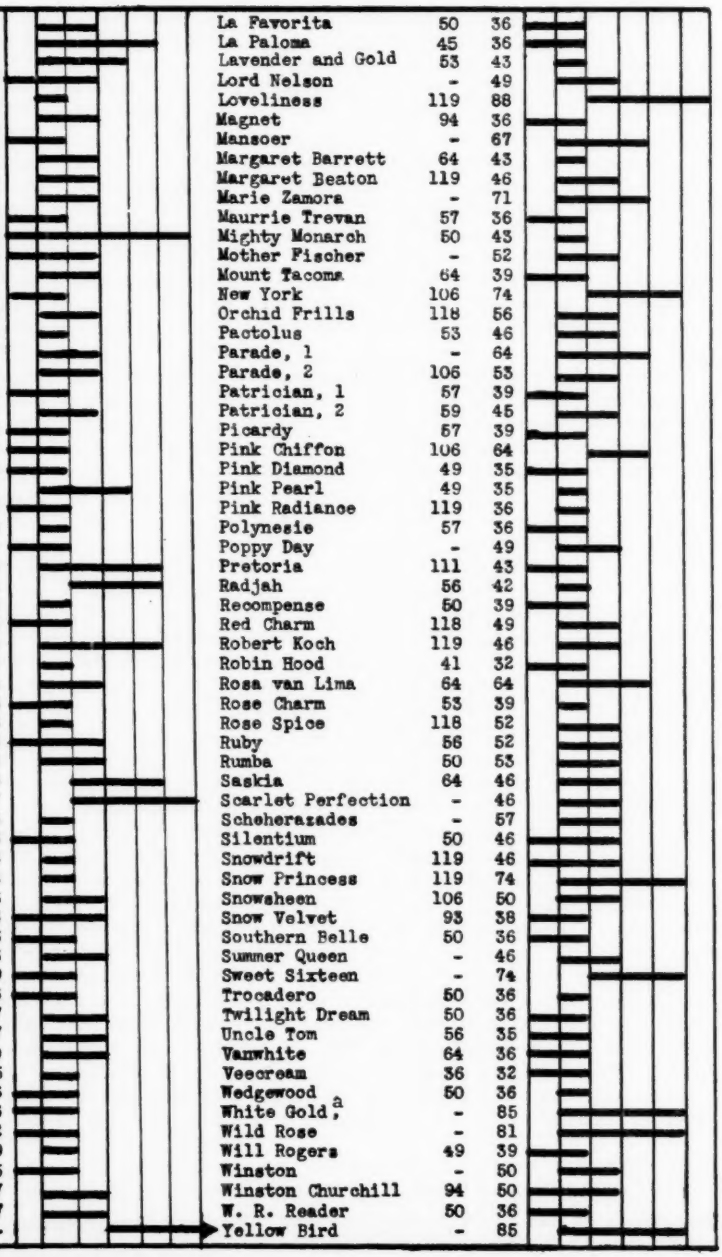
The high incidence of yellows within the controls, and the recorded data for the variety Carnival indicated inherent weaknesses in this type of experiment. Field-grown corms prob-

[1] Pathologist and Geneticist, respectively, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, Beltsville, Maryland.

[2] McClellan, W. D., and R. L. Pryor. 1957. Susceptibility of gladiolus varieties to Fusarium, Botrytis, and Curvularia. Plant Disease Reptr. 41: 47-50.

Table 1. Days to Fusarium yellows expression in 100 percent of shoots and elapsed time in weeks from first symptoms using 16 inoculated and 8 control corms for each 119 gladiolus varieties.

Variety	Days to symptoms Cont:	Days to symptoms Inoc	Variety	Days to symptoms Cont:	Days to symptoms Inoc
American Beauty	106	57	La Favorita	50	36
Apricot Glory	-	74	La Paloma	45	36
Arlpas	-	64	Lavender and Gold	53	43
Artist	63	45	Lord Nelson	-	49
Benjamin Britten	53	36	Loveliness	119	88
Bolero	59	49	Magnet	94	36
Bouton D'Or	-	36	Mansoer	-	67
Bridesmaid	-	52	Margaret Barrett	64	43
Buckeye Bronze	-	50	Margaret Beaton	119	46
Butterscotch	50	46	Marie Zamora	-	71
Calvary	50	39	Maurrie Trevan	57	36
Carnival	57	95	Mighty Monarch	50	43
Carrara	53	53	Mother Fischer	-	52
Carved Ivory	-	57	Mount Tacoma	64	39
Caswallon	45	36	New York	106	74
Cathay	-	50	Orchid Frills	118	56
Chatterbox	57	36	Pactolus	53	46
Chief Pontiac	64	46	Parade, 1	-	64
Citation	106	46	Parade, 2	106	53
Colonial Dame	64	36	Patrician, 1	57	39
Convoy	-	46	Patrician, 2	59	45
Dainty Miss	46	36	Picardy	57	39
Danzig	57	36	Pink Chiffon	106	64
Dauntless, 1	119	36	Pink Diamond	49	35
Dauntless, 2	50	64	Pink Pearl	49	35
Debutante, 1	57	39	Pink Radiance	119	36
Debutante, 2	49	35	Polynesie	57	36
Donna	59	42	Poppy Day	-	49
Dusk	-	74	Pretoria	111	43
Easter Parade	-	74	Radjah	56	42
Eighth Army	57	43	Recompense	50	39
Elizabeth the Queen	106	36	Red Charm	118	49
Exemplar	-	74	Robert Koch	119	46
Firebrand	49	42	Robin Hood	41	32
Fire Opal	-	56	Rosa van Lima	64	64
Francesca	-	35	Rose Charm	53	39
Gene	56	35	Rose Spice	118	52
General Patton	106	46	Ruby	56	52
Golden Gate	-	53	Rumba	50	53
Golden Ophelia, 1	-	78	Saskia	64	46
Golden Ophelia, 2	-	87	Scarlet Perfection	-	46
Golden State	106	43	Scheherazades	-	57
Gray Summit	50	36	Silentium	50	46
Hawaii	119	43	Snowdrift	119	46
Hollywood	119	36	Snow Princess	119	74
Innocense	119	36	Snowsheen	106	50
Ivy Robertson	-	56	Snow Velvet	93	38
Jay's Joy	53	36	Southern Belle	50	36
Jeanette White	57	46	Summer Queen	-	46
Je Maintiendrai	119	39	Sweet Sixteen	-	74
Joy Isabella	106	36	Trocadero	50	36
Kerry Dancer	50	57	Twilight Dream	50	36
King Click, 1	64	57	Uncle Tom	56	35
King Click, 2	61	50	Vanwhite	64	36
King David	56	35	Veecream	36	32
Kittyhawk	45	36	Wedgewood	50	36
Klondike	57	36	White Gold,[a]	-	85
Lady Anne	49	42	Wild Rose	-	81
Lady Boo	50	39	Will Rogers	49	39
Lady Eve	59	35	Winston	-	50
Lady Jane, 1	-	57	Winston Churchill	94	50
Lady Jane, 2	106	57	W. R. Reader	50	36
Ladykiller	-	-	Yellow Bird	-	85



[a] See Table 2 for White Gold, 2.

Table 2. Days to Fusarium yellows expression in 100 percent of shoots and elapsed time in weeks from first symptoms using 10 to 15 inoculated and 5 to 7 control corms for each of 42 gladiolus varieties.

Variety	Days to symptoms Cont:	Inoc	Weeks for spread of symptoms 4 6 8 10 12 14	Variety	Days to symptoms Cont:	Inoc	Weeks for spread of symptoms 4 6 8 10 12 14
Alice Adams	-	-		Jack Pot	118	56	
Anthony Fokker	-	35		Jo Wagenaar	-	59	
Atlantic	56	38		Lovelace	105	35	
Beauty's Blush	-	52		Lovely Lady	59	38	
Belle Jaune	63	38		Mallow	93	35	
Buckeye Queen	49	35		Oriental Pearl	93	38	
Caribbean	85	42		Phipps Jr.	44	35	
Charmaine	52	35		President Truman	56	38	
Columbia	-	52		Purple Burma	118	80	
Corona	52	35		Robinson	56	35	
Coutts' Orchid	35	35		Rosita	118	35	
Daisy Mae	118	42		Sans Souci	105	56	
Devotion	56	45		Silver Sword	52	38	
Drum Major	49	35		Simon Leelgwater	56	35	
Early Purple	-	45		Snowclad	118	35	
Easter Morn	118	49		Skyrocket	-	80	
Elmer's Rose	118	45		Spotlight	59	45	
Friendship, 1	-	52		White Gold,[a]	118	94	
Friendship, 2	-	52		White Lace	44	35	
Frosty	105	49		Winter White	118	56	
Ghenghis Khan	63	35		Wagner's Rhinegold	63	56	
High Finance	-	35					

[a] See Table 1 for White Gold, 1.

ably introduced a number of pathogenic isolates that were subsequently distributed throughout the planting, and it is probable that different strains with varying patterns of pathogenesis occurred in corms of a single variety. The introduction of one or more virulent isolates into one section of one bench could account for yellowing of 100 percent of the shoots in uninoculated controls of a variety before or at the same time that shoots in the inoculated replications became 100 percent symptomatic. The long interval between initial symptom expression and development of symptoms in 100 percent of the shoots such as occurred in the variety Carnival might be caused: 1) by individual responses of varieties occurring in a mixture, in which case there should be two or more peaks in the pattern of infection, as shoots of the two or more varieties yellowed; 2) by a bench effect reflecting varietal sensitivity to ranges of moisture, temperature, and light among duplications of the same variety planted in the same or different locations; or 3) by a combination of these variables. One of the two treated groups of Carnival was planted in the middle of a row in the center of a bench on the east side of the greenhouse and the other at the west edge of a bench located on the west side of the greenhouse. All the shoots in the west bench were symptomatic by the sixth week, whereas those shoots in the east bench were just beginning to develop symptoms. Many of the shoots that developed symptoms early did not die. Most of the shoots that yellowed developed flowers, and all were typical of the variety Carnival. Data for units of corms that proved to be mixtures of two or more varieties were discarded.

Five corms each of nine varieties in the main experiment were separately inoculated with each of the six isolates. By using yellowing of 100 percent of the germinated shoots to indicate complete infection, isolates V, 304, O, and B were found to be highly virulent in descending order when compared with other isolates and with the control group. However many additional varieties, the control groups for which prove to be uninfected, will have to be screened with the individual isolates to select those which will provide patterns of pathogenesis most useful for determining virulence of isolates on hand and for selecting isolates with desirable patterns of pathogenesis as replacements for those whose virulence has been reduced.

CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

DAMPING-OFF OF GUL MOHUR (DELONIX REGIA RAF.) IN INDIA[1]

N. Sharan

A severe damping-off disease was observed in seedlings of Gul Mohur [royal poinciana] (Delonix regia Raf.) during July 1955 at the Botanical Garden of Government Agricultural College, Kanpur. The incidence of the disease was 35 percent. As Gul Mohur is an ornamental tree of great value in landscape gardening in India, investigations on the disease were taken up, the results of which are briefly reported here.

Death of seedlings due to the disease was observed both in pre- and post-emergence stages. Affected seedlings in the pre-emergence stage develop brown patches which gradually turn darker in colour and become soft. It was also observed that some seeds get infected after sowing and become shrunken and deformed; such seeds do not germinate at all. In the post-emergence stage, the disease is manifested by abrupt collapsing of the seedlings. The course of the disease in affected seedlings was carefully studied and the first symptom was the appearance of light-brown, discoloured areas on the plant, starting from the root region and progressing upward to the stem and also to the leaves. Thus, gradually, all the parts of young seedlings become affected. The light-brown areas later turn darker and sometimes nearly black in appearance and ultimately the seedling collapses and dies. In advanced stages of infection, particularly under humid conditions, the affected seedlings emit a foul odour and sometimes a cottony fungus growth develops on the rotting parts of the plants.

Microscopic examination of transverse sections of the diseased portion of the stems showed the presence of mycelium composed of coenocytic, hyaline hyphae. The mycelium was both intra- and intercellular. The epidermis became brown in colour in the very early stages as a result of infection. Disintegration of cells was clearly observed in epidermal and cortical regions. The mycelium was largely localized in the cortical tissues only, but in some cases it was found to penetrate the vascular bundles and the pith. Sporangia and oospores occurring in the diseased tissues were rarely observed.

The disease generally affects the seedling in the young stage when cork-cambium and fibro-vascular bundles are not fully developed. Seedlings 3 to 10 days old were found to be most vulnerable to the disease. Old plants are not affected because of lignification, which offers resistance to the disease.

Isolations were made from diseased portions of the seedlings on 2 percent potato-dextrose agar medium and a Pythium sp. was invariably obtained. The Pythium sp. thus isolated was found to be pathogenic when seedlings of Gul Mohur were inoculated.

Cultural studies were carried out both on synthetic and non-synthetic media, viz., rice agar, potato-dextrose agar, oat meal agar, maize meal agar, Richard's agar and Elliot's agar. The fungus grew very well on potato-dextrose medium and almost as well on maize meal agar and oat meal agar media. Synthetic media like Richard's agar medium and Elliot's agar medium were not found very suitable.

On the basis of cultural and morphological studies and in accordance with Sideris[2], the causal organism is identified as Pythium debaryanum Hesse.

In host range studies P. debaryanum from Gul Mohur was found to cause damping-off of seedlings of tomato (Lycopersicon esculentum), egg plant (Solanum melongena), cauliflower (Brassica oleracea var. botrytis), hollyhock (Althaea rosea) and Saponaria sp.

Preliminary experiments were made to devise suitable control methods for the disease and, in this connection, some seed and soil treatments were tried. Agrosan G.N., Ceresan M, Copper carbonate and cuprous oxide (Cuprocide) were used for seed treatment and formalin for soil treatment. Different strengths of the fungicides were used and observations were recorded on the disease incidence in relation to pre- and post-emergence stages of seedlings. Whereas soil treatment with 3 percent formalin gave the best results, Ceresan M (1:50) was the most effective of all fungicides used for seed treatment.

There appears to be no previous record of damping-off of Delonix regia caused by Pythium debaryanum.

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[1] Thesis submitted in partial fulfillment of the requirements for degree of M. Sc. (Ag.) Plant Pathology of the Agra University, Agra, India.

[2] Sideris, C. P. 1932. Taxonomic studies in Pythiaceae. Mycologia 24: 14-61.

PLANT DISEASES OF ECONOMIC CROPS OCCURRING IN WYOMING DURING 1958[1]

Arlen D. Davison[2]

During the spring and summer of 1958 the weather in most of Wyoming was unseasonably wet. This situation was very favorable for the development of a number of plant diseases.

Following is a résumé of diseases which caused crop losses, as well as several that are not normally prevalent within Wyoming.

1. Bean rust, incited by Uromyces phaseoli (Pers.) Wint. v. typica Arth., occurred in epiphytotic proportions in southeastern Wyoming on Great Northern and Pinto varieties of field beans. This year was the first in several years that the rust has been generally present in more than trace amounts. The disease developed in mid-August as the beans were maturing but fortunately little loss in yield was sustained because of the disease. There was also a trace of rust in northwestern Wyoming.

2. Sclerotinia wilt or white mold caused by Sclerotinia sclerotiorum (Lib.) D By. was a serious disease of beans in northern Wyoming. Many farmers suffered a 10 to 25 percent loss because of the disease.

3. Fusarium solani (Mart.) Appel & Wr. f. phaseoli (Burkh.) Snyd. & Hans. root rot was moderate to severe in bean fields throughout the State.

4. Common and halo bacterial bean blights caused by Xanthomonas phaseoli (E. F. Sm.) Dows. and Pseudomonas phaseolicola (Burkh.) Dows., respectively, were light in incidence throughout the State this year. Only a trace of damage was sustained in Park County.

5. Downy mildew of alfalfa, Peronospora trifoliorum D By., was very prevalent and severe throughout the State this year. One of the most severely infected areas was the elk refuge near Jackson, Wyoming, which had an incidence of 50 to 75 percent.

6. Common corn rust, incited by Puccinia sorghi Schw., occurred in several fields in eastern Wyoming. Pustules were observed only on border rows of sweetcorn surrounding field corn. The infection was not sufficiently heavy to cause economic damage. Only within the past 5 years has the disease been encountered within the State and then only in localized areas.

7. Stripe rust of wheat occurred throughout the State. Until 1 year ago Puccinia glumarum (Schm.) Eriks. & E. Henn. was not prevalent but this year caused an estimated 3 to 5 percent loss in winter wheat.

Black stem rust, Puccinia graminis Pers. f. sp. tritici (Eriks. & E. Henn.) and leaf rust, Puccinia recondita Rob., were present in only trace amounts, thus causing little or no loss to the farmer.

8. Curly top of sugar beets caused an estimated 2 to 5 percent loss in yield in several fields in central Wyoming. The infection occurred when the beets were about one-half developed and thus did not result in a large reduction in yield.

9. Rhizoctonia disease of sugar beets occurs each year in trace amounts in all sugar beet-growing regions in Wyoming. This year in Platte County, however, a 15-acre field was heavily infested with Rhizoctonia solani Kuehn, which resulted in a 30 to 40 percent loss of the crop.

10. Puccinia graminis Pers. severely infected a lawn of Marion bluegrass in Platte County with the resulting loss of turf vigor.

11. In west-central Wyoming black stem of alfalfa, as well as leaf spot (caused by Pseudopeziza medicaginis (Lib.) Sacc.), caused minor loss in seed production. In many fields 50 percent of the leaves dropped because of the disease complex. Fortunately, the seed set was nearly complete when the plants were infected and little loss from the disease is expected.

12. Albugo candida (Pers. ex Chev.) Kuntze caused some loss in radish seed production in northern Wyoming. Radish-seed acreage in the State is small, but is a high-value cash crop. As a result of the white rust an estimated 1 to 2 percent loss was sustained.

13. Gray speck of winter wheat could be found in most fields because of mineral deficiencies in the alkaline soils of Wyoming.

14. Septoria leaf blotch, caused by Septoria tritici Rob. ex Desm., occurred throughout the State in winter wheat. The disease was most prevalent in southeastern Wyoming. Little if any reduction in yield was attributed to the infection.

15. Corn smut, Ustilago maydis (DC.) Cda.; loose smut of oats, Ustilago avenae (Pers.) Rostr.; loose smut of barley, Ustilago nuda (Jens.) Rostr.; loose smut of wheat, Ustilago

[1]Published with approval of the Director, Wyoming Agricultural Experiment Station, as Journal Paper No. 120.

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tritici (Pers.) Rostr.; and stinking smut or bunt of wheat, caused by Tilletia caries (DC.) Tul. and Tilletia foetida (Wallr.) Liro, occurred throughout the State in trace amounts.

16. Ergot, Claviceps purpurea (Fr.) Tul., could be observed on species of many genera of Gramineae. Damage to the cultivated grasses such as Bromus, Agropyron, and Poa spp. was minor, as it was on varieties of wheat, barley, and rye within the State.

17. Western wheat streak-mosaic caused considerable damage in isolated areas last spring. This fall the virus disease has been observed to be more general than last year in fall stands of winter wheat. The results of this fall infection will not be known until spring.

18. Fire blight of apple caused by Erwinia amylovora (Burr.) Winslow et al. was common in most apple orchards and on some ornamental crab trees. Very few growers made any effort to control the disease since fruit-growing is a sideline in their farming program.

19. Potato diseases again caused the usual problems to growers including 1/10 of 1 percent ring rot, Corynebacterium sepedonicum (Spieck. & Kotth.) Skapt. & Burkh., infection in potato fields entered for certification. Leaf-roll infection accounted for 1 percent loss. Rhizoctonia disease of potato was very common in all fields, as were several of the mosaic diseases of potatoes.

20. Mosaic of red raspberries was common in western Wyoming. All raspberries in the area are grown in home gardens and therefore no attempt is usually made by the grower to destroy the infected plants.

WYOMING AGRICULTURAL EXPERIMENT STATION, LARAMIE

UNUSUAL OCCURRENCE OF CERTAIN PLANT DISEASES IN KENTUCKY IN 1958

E. M. Johnson and R. A. Chapman

Low temperatures and higher-than-normal rainfall occurred throughout the State during spring planting and the early growing season. Even after temperatures became normal heavy rains continued until early August. Because of these conditions many plant diseases were numerous and caused greater damage than usual.

Tobacco Plant Bed Diseases: Wildfire, Pseudomonas tabaci, was less prevalent in tobacco beds than in previous seasons although conditions appeared ideal for its development. The increased use of wildfire resistant varieties and a dry May probably account for less wildfire in tobacco beds than in previous seasons.

Anthracnose, Colletotrichum destructivum, was present in many tobacco beds, especially in the southwestern part of the State; however, the disease was present in limited amounts in other parts of the State.

Cold injury was present in most tobacco beds but appeared to cause little or no damage.

Blue mold, Peronospora tabacina, appeared in a few plant beds after transplanting was almost over. Symptoms consisting of small dead flecks were so mild and atypical that they went unnoticed by growers.

Field Diseases of Tobacco: Pythium soft rot, Pythium spp., of tobacco occurred throughout the State in greater amounts than ever before recorded. The disease, developing a week to 10 days following setting, caused a soft rot of the stems that started at or just below the soil surface. The number of plants killed varied from a few to as many as 70 percent in some fields. Reports of destruction of 25 percent of the plants were not unusual. The disease was more prevalent following the late turning under of winter grain cover crops but was recorded following bluegrass, fescue and red clover sods. When great numbers of plants were killed it was found that disking the field and resetting the entire crop, placing the new rows a foot or so from the original ones, was more effective than hand setting where plants had died. Where entire fields were reset no further damage from soft rot occurred, whereas some growers reported that they had to reset as many as two or three times where plants were reset by hand in places where plants had been killed by soft rot.

Sore-shin, Rhizoctonia solani, developed earlier than usual. As in past years, only an occasional plant in a field was affected. Rhizoctonia was frequently found on the roots of plants making poor growth.

Black shank, Phytophthora parasitica var. nicotianae, developed as soon as 2 or 3 weeks after setting in some fields. There have been some reports of black shank on farms where there has been no previous report of the disease, but it is too early to tell whether there has been a great increase in the number of farms affected. The recognition of black shank has been complicated by the great amount of drowning following almost daily heavy rains during July.

Anthracnose has been present in some tobacco beds since 1935 but was reported for the first time in the State as a field disease of tobacco. The leaves of affected plants were covered with circular to irregular necrotic spots 1/8 to 1/4 inch in diameter that were thought by some growers to be either wildfire or angular leaf spot. Dead, lens-shaped depressed spots were present on the undersides of midribs, and sometimes on stems and some secondary veins. Affected plants were yellowed and were often distorted and dwarfed. Acervuli bearing setae and spores were present in the dead spots or developed overnight when affected leaves were placed in moist chambers. Some growers reported that diseased plants had made little or no growth in midseason in fields where anthracnose-free plants were waist high and taller. Other growers reported that after a severe initial attack plants recovered after a time and grew normally. Sometimes the only symptom on large plants was the presence of depressed dead areas on the undersides of midribs, which often caused the leaves to break and wilt. Anthracnose appeared to affect all burley varieties and was reported in one field of dark air-cured tobacco. Observations suggest that where plants appeared to be greatly retarded by anthracnose actually they were retarded by something else, giving the anthracnose a chance to build-up on the retarded plants. Normally growing plants near by might have a few spots but were not seriously damaged.

In a number of fields anthracnose appeared to come from infected plant beds. Growers

reported that anthracnose developed in plants from certain diseased beds, whereas plants in the same field from beds that appeared free of disease were free of anthracnose.

Manganese toxicity was present in greater amounts in tobacco than has ever before been recorded. Affected plants grew slowly after setting, were light greyish-green to yellowish between the larger veins, and numerous small dead spots similar to phosphorus deficiency spots were present on older leaves. Manganese toxicity occurred on soils with pH 4.2 to 5.2. The leaves of affected plants contained 4000 to 7300 parts per million of manganese. When affected plants were transplanted to weakly acid greenhouse soil they recovered quickly and grew normally. When lime was added to field soil where manganese toxicity occurred affected plants soon recovered.

Chemical injuries from weed and brush killers and from injudicious use of organic insecticides were present in many fields. Usually these injuries were slight and affected plants soon developed new leaves free of distortion. Despite repeated warnings growers still use sprayers for applying insecticides that have previously been used to apply weed killers, which often results in damage to tobacco. Some injuries were traced to weed and brush killers applied along utilities' lines or highways.

Black root rot, Thielaviopsis basicola, was present in resistant varieties of burley in different areas of the State. This is attributable to the cold, wet setting season.

Leaf spotting. What appeared to be temporary phosphorus starvation spotting was present in many tobacco fields. Affected plants grew slowly, were yellowish green, and numerous necrotic spots resembling incipient frogeye or anthracnose developed on older leaves during the first few weeks following setting. This occurred on soils low in phosphorus and on those to which liberal amounts of phosphorus had been applied. Usually after a time affected plants developed new leaves free of chlorosis and necrotic spots but they never attained the size of unaffected plants in the same field. It is believed that the organisms that break down green organic matter were delayed in their action because of low soil temperatures and high soil moisture and that the newly set tobacco was in competition with these organisms for the limited available phosphorus supply around each newly-transplanted plant. Recovery usually occurred when the decay of organic matter was well advanced and the roots occupied a greater volume of soil.

Wildfire was present in many fields of burley tobacco. Spots were numerous on many leaves, and yellowing of top leaves from bacterial toxin was prominent in many plants. Resistant and susceptible burleys were sometimes planted in the same fields. Resistant varieties were almost free of wildfire spots, whereas susceptible varieties were greatly injured.

Angular leaf spot, Pseudomonas angulata, was present in tobacco fields after an almost complete absence of several years. It was not so widespread nor so destructive as wildfire. Wildfire-resistant varieties appeared resistant to angular leaf spot.

Curly top, probably caused by the sugar beet curly top virus, was present in burley tobacco and to a less extent in dark tobacco in widely scattered areas of the State. Usually only a plant or so per field was affected; however, one grower reported 12 curly top plants in a 3-acre burley field. There have been more reports of the disease than usual. A specimen was received from Adams County, Ohio and one from St. Joseph, Missouri. The disease is readily transmitted to tobacco by grafting.

Club root, a virus disease similar to the wound tumor virus, was identified in four fields in four central Kentucky counties. In two fields only a few plants were affected near the edge of the fields. Severe distortion of the growing point leaves, somewhat similar to early symptoms of curly top, occurred on many affected plants but late growth was normal. Two growers reported about 5 to 7 percent of the plants affected in fields of 5 and 7 acres, respectively.

Ring-spot, a virus disease, appeared to be more prevalent than usual.

Diseases of Sweet and Dent Corn: Seedling blight. During the cold, wet spring seedling blight of dent corn, probably caused by several different fungi singly and possibly in combination, was widespread and destructive. Affected plants varied from a few per field to almost total infection in some fields. In most cases the seed germinated well but after reaching a few inches in height the plants yellowed, ceased growing, and the lower leaves died. There was slight to marked purpling of the upper leaves, and slight to complete rotting of the roots. It was not unusual for fields to contain plants from a few inches to knee high. Growth was so poor in many fields that growers found it advisable to rework and replant entire fields.

Stewarts disease, Bacterium stewartii, was present and destructive in sweet corn often soon after emergence. Affected plants were dwarfed, pale green and many leaves per plant had dead longitudinal streaks from a fraction of an inch to a few inches long. In contrast to

plants affected with seedling blight, the roots were usually not rotted. In one county where sweet corn is grown commercially, growers found it necessary to replant entire fields.

Stewarts disease usually causes only leaf blight of dent corn late in the season. This spring in some fields young plants of hybrid dent corn developed symptoms typical in all respects to the disease as it occurs in sweet corn.

Tomato: Root knot, caused by Meloidogyne incognita, was identified in two fields of tomatoes. In a field of 5 acres, set with plants from Florida, all of the plants were affected. The plants were yellow, and dwarfed and most of the lower leaves were dead. Nearly all of the feeder roots were dead and other roots had prominent galls.

Gray mold, Botrytis cinerea, affected tomatoes in several plastic greenhouses following both Bibb and leaf lettuce. Soon after setting, some plants developed dead areas on the stems at or near the soil surface and collapsed. On other plants few to several leaves were killed. The fungus was fruiting abundantly on these leaves. On large plants green fruits 1/2 inch in diameter to half grown were rotted. Rotting usually started around or under the calyx but on some fruits rotting occurred wherever the fruits were touched by leaves that were covered with spores. Gray mold developed in spite of frequent dustings with carbamates.

Mosaic. In most plastic greenhouses all of the tomato plants were affected with tobacco mosaic. Inoculations to tobacco indicate that there are many different strains of the virus, some of which appear to cause great damage. Most growers make no attempt to control mosaic because they believe it does little damage. It is possibly responsible for some of the uneven ripening of some fruits and is certainly responsible for reduced yields.

Leaf mold, Cladosporium fulvum, was present in all plastic greenhouses observed and in some home gardens. In most houses carbamate dusts appeared to give satisfactory control.

In one plastic greenhouse tomato plants developed a chlorosis like that in tobacco having manganese toxicity. The pH of the soil was 4.5, and the foliage contained twice as much manganese as normal plants. The plants soon recovered when hydrated lime was applied to the soil.

Late blight, Phytophthora infestans, destroyed all the tomatoes in one plastic greenhouse. The tomatoes were set while late blight was present in a field next to the greenhouse. Late blight appeared in fields in eastern and central Kentucky in September.

Lettuce: Lettuce drop, Sclerotinia sclerotiorum, and gray mold, Botrytis cinerea, were present in both Bibb and leaf lettuce in plastic greenhouses. Gray mold was more prevalent and more destructive. In some houses the loss from gray mold was 50 percent. Losses of 10 to 15 percent were not unusual. It appears impossible to control gray mold with organic fungicides because of the very high humidities maintained in plastic greenhouses.

Bean: Gray mold, Botrytis cinerea, destroyed an entire crop of Kentucky Wonder pole beans in a plastic greenhouse just when they were ready for market.

Strawberry: Red stele, Phytophthora fragariae, was present in strawberry fields throughout the State. Affected plants were badly stunted and bore few fruits. Usually the disease occurred in poorly drained areas. Oospores were found in fleshy roots when thin sections were cleared in lacto-phenol.

There was less leaf scorch, Diplocarpon earliana, and leaf spot, Mycosphaerella fragariae, than in 1957.

Elm: Dutch elm disease, Ceratostomella ulmi, was identified in several elm trees near Princeton in the western part of the State.

Apple: Black pox, Helminthosporium papulosum, occurred on the fruits and twigs of Rome, Grimes and Golden Delicious apples in several orchards in Johnson County. Spots on the fruit were numerous and conspicuous. When twigs with papular, circular areas with torn margins were placed in a moist chamber, spores of Helminthosporium, like those illustrated in Plate III page 27 of West Virginia Bulletin 260, developed overnight.

KENTUCKY AGRICULTURAL EXPERIMENT STATION, LEXINGTON

BRIEF NOTES

HOJA BLANCA AND ITS INSECT VECTOR FOUND ON RICE IN A SECOND AREA IN THE UNITED STATES

By John G. Atkins, James P. Kramer, and S. D. Hensley[1]

Hoja blanca, an insect-transmitted virus disease of rice, was recently found for the second time in the United States. The disease was identified on October 1, 1958, in rice fields at two locations near Bay Saint Louis, Hancock County, Mississippi. In 1957 the disease was reported from near Belle Glade, Florida[2].

Sogata orizicola Muir, the only known insect vector for hoja blanca[3], was collected on September 3 and October 1 in a small rice field in Hancock County. While leaf symptoms somewhat suggestive of hoja blanca were observed on September 3, the disease was not recorded. However, on October 1 numerous plants showing characteristic disease symptoms were present. In addition, the disease was found on plants in another rice field where disease symptoms were not observed in early September. Previously, S. orizicola had been collected only near Belle Glade, Florida.

In early September a survey trip was also made through northern Florida, southeastern Georgia, and South Carolina for hoja blanca and S. orizicola. No rice was located in northern Florida, and rice in the other two States showed no evidence of infection or infestation. In surveys made in September and October in southern Louisiana, neither hoja blanca nor S. orizicola was found. S. furcifera (Horvath), a species not considered as a vector, was collected in both Mississippi and Louisiana.

CROPS RESEARCH DIVISION AND ENTOMOLOGY RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITES STATES DEPARTMENT OF AGRICULTURE

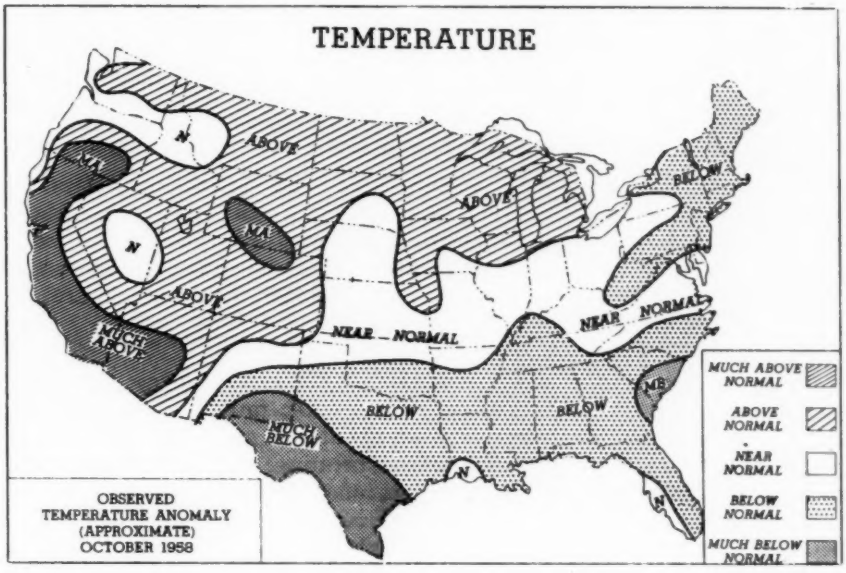
[1]Respectively, pathologist, Crops Research Division, and entomologists, Entomology Research Division, Agricultural Research Service, United States Department of Agriculture.

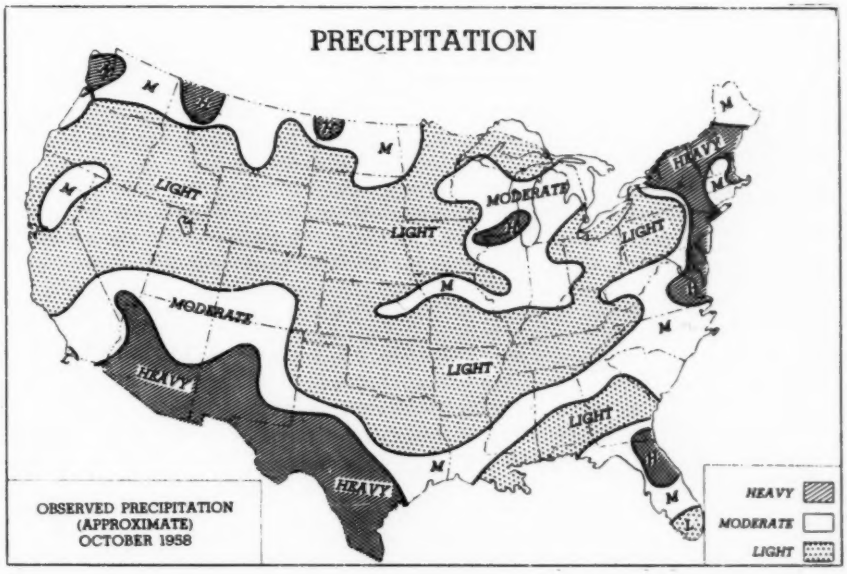
[2]Atkins, John G., and C. Roy Adair. 1957. Recent discovery of hoja blanca, a new rice disease in Florida, and varietal resistance tests in Cuba and Venezuela. Plant Disease Reptr. 41: 911-915.

[3]Atkins, John G., and Judson U. McGuire, Jr. 1958. The hoja blanca disease of rice. International Rice Commission Newsletter 7(3): 1-7.

CORRECTION

REPORTER, October issue (Volume 42, Number 10), page 1127: lines 13 through 20 are out of order, that is, beginning with, "in northwestern Illinois....." and ending with "the Clarion variety yielded 98 percent as much as Clintland during this period." These eight lines should follow the last sentence on the page to read as follows: "District losses for the Clinton variety ranged from 50 percent in southern Illinois to 28.7 percent in northwestern Illinois. The district percentage figures were in ...," etc.





The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time. Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.

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